**For Your 1895 Certificate Class,** p. 481.
By J. C. HOROBIN, M.A., Principal, Cavendish College, Cambridge, and Member of the School Board for London, see page 415.
MODEL ANSWERS TO SCHOLARSHIP QUESTIONS also appear in this Number.

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# The Practical Teacher

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*Wisdom is humble that he knows no more.'*—COWPER.

VOL. XV. NO. 8. FEBRUARY, 1895. PRICE, 6D. POST FREE, 8D.

## ARITHMETIC PRIZE PAPERS.

BY W. P. WORKMAN, M.A., B.SC.,
*Head Master of Kingswood School; late Fellow of Trinity College, Cambridge.*

### PAPER NO. II. [K. S., 1894].

1. Reduce to their lowest terms :—

(1) $\frac{234,333,333,333,099}{456,142,857,142,401}$

(2) $\frac{234,142,857,142,857,142,857,142,857,142,857,142,623}{345,076,923,076,923,076,923,076,923,076,923,076,578}$.

2. A can run 100 yards in 10″, B in $10\frac{1}{2}$″, C in $10\frac{2}{3}$″, D in $10\frac{3}{4}$″. B has 2 yards, C 4 yards, and D 6 yards' start. In what order will they come in, and what distance will separate the first from the last when the first finishes?

3. The number 1,053,924,187 is composed of three factors, the difference of the greatest and least of which is 8. What are they?

4. I look at my watch between 4 and 5. On looking again between 7 and 8 the hands have exactly changed places. When did I first look? (Lock's Arithmetic.)

5. I am informed that the reciprocal of an *integer* is ·000,102,553,6 ....., and requested to find the square root of the integer, and also its cube root. At what decimal place in my answers does the information conveyed in the word 'integer' become essential to accuracy?

6. Two boys, A and B, start to climb up two poles of the same height side by side. A's speed in ascending is to B's as 3 : 2, and A descends with twice the speed with which he ascends. How far up his pole will B be when A is level with him on his descent?

7. Find as many factors as possible of :—

(1) $3^{63}+1$; (2) $4^{63}+1$; (3) $4^{64}+2^{64}+1$.

8. Prove that in those years whose numbers are divisible by 400, *e.g.*, 2000, 2400, etc., the same date of the month is always the same day of the week.

In general if $\left[\frac{a}{b}\right]$ stand for the remainder when $a$ is divided by $b$, prove that for any year subsequent to 1752 the $p^{\text{th}}$ of October in the year $N$ A.D., is the $r^{\text{th}}$ day of the week (Sunday, $r=1$, etc.) when

$$r=\left[p+\frac{497N}{400}-\frac{1}{4}\left[\frac{N}{4}\right]+\frac{1}{100}\left[\frac{N}{100}\right]-\frac{1}{400}\left[\frac{N}{400}\right]\right].$$

9. Prove that if a number $N$ be the product of two unequal primes, $a$ and $b$ (other than 2 and 5), and if $\frac{1}{a}$ have $p$ figures in its circulating period, and $\frac{1}{b}$ have $q$ figures, $\frac{1}{N}$ will have $r$ figures, where $r$ is the L.C.M. of $p$ and $q$.

10. Prove that $\frac{1}{36,951,974,377,955}$ (base 10) is a mixed circulator with one non-recurring figure, the recurrence of which commences with the 1562nd figure.

11. It being given that 98999 and 49499 are both primes, show that if $\frac{1}{98,999}$ be converted into an infinite decimal, the 49489th, 49492nd, 49494th, 49497th, 49498th, 49500th–49503rd, 49505th, and 49507th figures, are either all 0 or all 9, while the 49475th, 49487th, 49493rd, 49496th, 49504th, 49506th, 49508th–49510th figures, are all 1 or all 8.

12. Show that if the denominator of a fraction be prime to the scale of notation, it is always possible to convert it into a circulating radical fraction, by finding first the last figure in the circulating period, and then the last but one, and so on, finding all the figures in the reverse order.

Deduce in this way that the figures of the circulating period of $\frac{1}{18237}$ (scale 12), beginning with the 3951st and ending with the 3960th (and last), are

$$27t\,181e\,957,$$

and verify this from the consideration that the given fraction

$$=\frac{1}{1e}+\frac{1}{31}+\frac{1}{35}.$$

### PAPER NO. I.—SOLUTIONS.

1. Since 30507813000 ends in three ciphers, it is clearly divisible by 125. Call the given number $N$, and let $f$ stand for 125. By ordinary division we have :—

$$\begin{aligned}\frac{N}{f}&=244062504\\&=244062500+4\\&=f\times 1952500+4\\&=f^2\times 15620+4\\&=f^2\{15625-5\}+4\\&=f^2\{f^2-5\}+4\\&=f^4-5f^2+4\\&=(f^2-1)(f^2-4);\end{aligned}$$

$$\therefore N=(f-2)(f-1)f(f+1)(f+2)$$
$$=\underline{123\times 124\times 125\times 126\times 127}.$$

*Second Solution.*—Since the product of 5 consecutive numbers, of which the middle one is $f$, is $f(f^2-1)(f^2-4)$, it is clear that it is only slightly less than $f^5$, unless $f$ be small. Hence the middle number of the series is the number nearest to the fifth root of the given number. The process of finding fifth roots is not ordinarily included in Arithmetics, but a boy who has been properly taught the

process of cube root ought to be able to extend it to fifth roots, especially if Horner's process is employed for cube roots (as in Pendlebury's 'Arithmetic'). The fifth root of the given number is 124·9919 ..... ; ∴ the middle factor is 125.

As none but the older Arithmetics, fortunately for schoolboys, make any mention of any rule for fifth root, our readers may be interested to see some of the stages in the work of finding this root for the number in question. Horner's method is not adopted, because, although more scientific and rather easier, the *raison d'être* is not so clear as in the process given.

| | | | | |
|---|---|---|---|---|
| 52 | 1000 | 10000 | 50000 | 3050781300̇0̇(124·9 |
| | 104 | 2208 | 24416 | 1 |
| | 1104 | 12208 | 74416 | 205078 |
| | | | | 148832 |
| 604 | 144000 | 17280000 | 1036800000 | |
| | 2416 | 585664 | 71462656 | |
| | 146416 | 17865664 | 1108262656 | 5624613000 |
| | | | | 4433050624 |
| | | | | 1191562376000 |

The algebraical key to the above process, which forms also the method for the extraction of the fifth roots of algebraical expressions, is as follows :—

$5a + b$ | $10a^2 + 5ab + b^2$ | $10a^3 + 10a^2b + 5ab^2 + b^3$

$10a^3 + 5ab^2 + b^2$ | $10a^3 + 10a^2b + 5ab^2 + b^2$

$5a^4$ | $N$ | $(a + b$

$10a^3b + 10a^2b^2 + 5ab^3 + b^4$ | $a^5$

$5a^4 + 10a^3b + \ldots\ldots + b^4$ | $N - a^5$ | $5a^4b + 10a^3b^2 + \ldots\ldots b^5$

$N - (a + b)^5$, etc.

We advise any one who wishes to practise this interesting rule to use the largest size paper at his disposal. Folio size will be necessary if he aspires to 10 places of decimals in his answer.

2. On the level the two trains run at the same rate ; ∴ the difference of time is wholly caused by the incline. Thus the incline causes a difference of 6 hours.

Now with a velocity $\frac{9}{10}$ths of the velocity on the level, the time taken is $\frac{10}{9}$ths of the time for the same distance on the level.

With a velocity $\frac{11}{10}$ths of the velocity on the level, the time taken is $\frac{10}{11}$ths of the time for the same distance on the level.

∴ 6 hours is the difference between $\frac{10}{9}$ths and $\frac{10}{11}$ths of the time taken for the incline supposed levelled.

∴ The time taken for the length of incline on the level is $\frac{6}{\frac{10}{9} - \frac{10}{11}}$ hours = 29·7 hours.

Hence the train *to* B is $\frac{10}{11} \times 29{\cdot}7$ hours = 27 hours } on the
,, ,, *from* B is $\frac{10}{9} \times 29{\cdot}7$ ,, = 33 ,, } incline.

Hence the journey is thus divided:—

| | Level. | Incline. | |
|---|---|---|---|
| Train to B - - | 6 d. 9 h. | 27 h. | = 7 d. 12 h. |
| Train from B - - | 6 d. 9 h. | 33 h. | = 7 d. 15 h. |

Let us consider firstly the trains which are met before we come to the incline, and note that a train is due AT A every day at 6 a.m.

Train due at A—

| | | |
|---|---|---|
| Tuesday, | 6 a.m. | Since we start on Monday at 8 a.m. and travel at the same rate as it is approaching, we meet it 11 hours after starting, that is, Monday, 7 p.m. |
| Wednesday, | 6 a.m. | We meet this 12 hours later, *i.e.*, 23 hours after starting, *i.e.*, Tuesday, 7 a.m. |
| Thursday, | 6 a.m. | Met on Tuesday 7 p.m., 35 hours after starting. |
| Friday, | 6 a.m. | Met on Wednesday 7 a.m., 47 hours after starting. |
| Saturday, | 6 a.m. | Met on Wednesday 7 p.m., 59 hours after starting. |
| Sunday, | 6 a.m. | Met on Thursday 7 a.m., 71 hours after starting. |
| 2 Monday, | 6 a.m. | Met on Thursday 7 p.m., 83 hours after starting. |
| 2 Tuesday, | 6 a.m. | Met on Friday 7 a.m., 95 hours after starting. |
| 2 Wednesday, | 6 a.m. | Met on Friday 7 p.m., 107 hours after starting. |
| 2 Thursday, | 6 a.m. | Met on Saturday 7 a.m., 119 hours after starting. |
| 2 Friday, | 6 a.m. | Met on Saturday 7 p.m., 131 hours after starting. |
| 2 Saturday, | 6 a.m. | Met on Sunday 7 a.m., 143 hours after starting. |

We shall reach the incline now before meeting another train. When we are at the top of the incline 153 hours after starting, *i.e.*, on Sunday at 5 p.m., the train next to be met, which is due at A on Sunday (next following) at 6 a.m., has 157 hours still to run, *i.e.*, will be on the incline for 4 hours more. Now since the velocities are as 11 : 9,

∴ Vel. of train to A : vel. of train to B : relative vel. of approach
:: 9 : 11 : 9 + 11.

∴ A distance which is covered by the train to A in 4 hours is covered by the two together in in $\frac{9}{20}$ of 4 hours = $1\frac{4}{5}$ hours ;

∴ these trains pass on Sunday at 6.48 p.m.

Consider the position at midnight on Sunday. We are 20 hours from B. The train which we shall next meet left B on Sunday at noon, and is, therefore, 12 hours of its travelling out from B. But what this train does in 12 hours, we should accomplish in $\frac{9}{11} \times 12$ hours = $9\frac{9}{11}$ hours.

∴ We are $20 - 9\frac{9}{11}$ hours distant from the present position of this train ; we shall, therefore, meet it in $\frac{11}{20}\{20 - 9\frac{9}{11}\}$ hours = $(11 - \frac{108}{20}) = (11 - 5\frac{8}{5})$ hours = $5\frac{8}{5}$ hours.

∴ These trains pass on Monday at 5.36 a.m.

Consider the position at midday on Monday. A train is just leaving B. We are still 8 hours from B. We shall meet this train in $\frac{11}{20}$ of 8 hrs., *i.e.*, $4\frac{8}{5}$ hours.

∴ We pass the last train Monday at 4.24 p.m.

3. (a)

59)100(·1694915
59
410
354
560
531
290
236
540
531
90

59 × 1 = 59
× 2 = 118
× 3 = 177
× 4 = 236
× 5 = 295
× 6 = 354
× 7 = 413
× 8 = 472
× 9 = 531

Since 90 is one-sixth of 540, the process may be continued at this point by dividing the last figure by 6, thus—

| | |
|---|---|
| 9 | |
| 1 | carry 3 making 31 |
| 5 | ,, 1 ,, 15 |
| 2 | ,, 3 ,, 32 |
| 5 | ,, 2, etc., etc. |
| 4 | |
| 2 | |
| 3 | |
| 7 | |
| 2 | |
| 8 | |
| 8 | |
| 1 | |
| 3 | |
| 5 | |
| 5 | |
| 9 | |
| 3 | |
| 2 | |
| 2 | |
| 0 | |
| 3 | |
| 3 | |
| 8 | |
| 9 | |
| 8 | |
| 3 | |
| 0 | |
| 5 | |
| 0 | |
| 8 | |
| 4 | |

BRITISH MUSEUM

We now note that the half of our period is appearing, and, as it *must* come sooner or later, we are justified in finishing by dividing by 2, thus:—

Ans. = ·016,949,152,542,372,881,355,932,203,389,830,50
8,474,576,271,186,440,677,966,1.

In verification of this we observe that it contains 58, = 59 − 1, figures, which is correct, since 59 is prime.

3. ($\beta$) Since $\frac{p}{n} + \frac{n-p}{n} = 1 = \cdot 9999\ldots\ldots$ (for ever), it follows that $\frac{n-p}{n}$ may be obtained from $\frac{p}{n}$ by subtracting every figure of the recurring period from 9, and that it will contain the same number of figures in the recurring figures.

The given conditions involve that $\frac{p}{n}$ and $\frac{n-p}{n}$ are both pure circulators.

Example: $\frac{1}{7} = \cdot\dot{1}42857$
$\frac{6}{7} = \cdot 8571\dot{4}2$
$\frac{7}{7} = \cdot\dot{9}9999\dot{9}$

4. 27722 being the product of two consecutive integers, it follows that these two integers must be the number next below the square root and the number next above it. The square root is found at once as 166...

$$\therefore\ 27722 = 166 \times 167;$$
$$\therefore\ \frac{1}{27722} = \frac{1}{166} - \frac{1}{167}.$$

Now, $\frac{1}{166} = \frac{1}{2\times 83}$; consider, therefore, the decimal corresponding to $\frac{1}{83}$. Since 83 is a prime number, it follows by a well-known law that the number of places in the period of $\frac{1}{83}$ must be 83–1, or a submultiple of this. The factors of 82 are

1, 2, 41 and 82;

$\frac{1}{83}$ may, therefore, have 1, 2, 41 or 82 places. We must convert it into a decimal to examine this.

This is readily done, and it is found that $\frac{1}{83}$ is a pure circulator of 41 places.

Similarly $\frac{1}{167}$ must have either 1, 2, 83 or 166 figures in its period. There is no method of saying which of these numbers may be chosen, save by converting the number into a decimal. In so doing it is found at the 84th place that recurrence does *not* occur; ∴ without continuing further we know that $\frac{1}{167}$ is a pure circulator of 166 figures.

The conversion of $\frac{1}{167}$ is readily accomplished thus:

```
·167)1000(·005988
      835
     1650
     1503
     1470
     1336
     1340
     1336
        4
```

The process may now be continued by dividing the figures already found by 25, since $4 = \frac{100}{25}$.

$\therefore \frac{1}{167} = \cdot 005988$
0239 carry 13, thus making (13)0239 to divide.
5209
5808
3832
3353
2934
1317
3652
6946
1077
8443
1137
7245
5089
8203
5928
1437
1257
4850
2994,

and as we have now carried it to the 86th place without recurrence it must go on to the 166th place.

Now since $\frac{1}{83}$ is a pure circulator of 41 figures,
$\therefore \frac{2}{83}$ ,, ,, ,, ,,
$\therefore \frac{10}{166}$ ,, ,, ,, ,,
$\therefore \frac{1}{166}$ ,, mixed circulator with 1 non-recurring and 41 recurring figures.

But $\frac{1}{167}$ is a pure circulator of 166 places; $\therefore \frac{1}{166} - \frac{1}{167}$ is a mixed circulator with 1 non-recurring figure and {L.C.M. of 41 and 166} recurring figures, *i.e.*, with 1 non-recurring and 6,806 recurring figures. ∴ the recurrence commences with the

{1 + 6806} + 1th figure, *i.e.*, the 6,808th figure.

5. Since 383 is a prime number, as may be easily proved by testing it for divisibility by all the primes less than its square root, *i.e.*, up to 19, it follows that $\frac{1}{383}$ must be a pure circulator with either 1, 2, 191, or 382 figures. There is no way of deciding which of these alternatives to adopt save to find the figures as far as the 192nd, at which place recurrence will *not* take place. ∴ the circulator contains 382 figures.

This is, however, a very short process:—

```
383)1000(·002610996057441 25
    766
    2340
    2298
     420
     383
      3700
      3447
       2530
       2298
        2320
        2298
         2200
         1915
          2850
          2681
           1690
           1532
            480
            383
             970
             766
              2040
              1915
               125
```

383 × 1 = 383
× 2 = 766
× 3 = 1149
× 4 = 1532
× 5 = 1915
× 6 = 2298
× 7 = 2681
× 8 = 3064
× 9 = 3447

; this being $\frac{1}{8}$ of 1000, the rest of the work can be accomplished at once by dividing by eight;

$\therefore \frac{1}{383} = \cdot 002610996057441 25$
32637075718015
66579634464751
95822454308093
99477806788511
74934725848563
96866840731070
49608355091383
81201044386422
97650130548302
87206266318537
85900783289817
23237597911227
1540469 ; and as recurrence does not now take place it follows that there are 382 figures.

If $N$ represented the number formed by the figures of the recurring period, it follows therefore that

$$\frac{1}{383} = \frac{N}{\text{The number formed by 382 nines}}$$
$$= \frac{N}{\{\text{The number formed by 191 nines}\} \times \{1,00\ldots(190\text{ noughts})1\}}$$

Now 383 cannot divide into the number formed by 191 nines, for if it did, $\frac{1}{383}$ would form a circulator of 191 figures;

∴ 383 divides into the other factor of the denominator, *i.e.*, into $10^{191} + 1$.

But $10^{10}+1$ is divisible by $10+1$, $\therefore$ it is also divisible by $11 \times 313 = 4213$.

[This is a particular case of a very general theorem, that if $n$ and $2n+1$ are both primes,

$$\frac{10^n+1}{2n+1}$$

is an integer, subject to certain limitations as to the value of $n$ which are very obscure. The theorem is true if $n=3$, and *not* true if $n=2$. It is true also when $n=5$, $n=11$, $n=23$, $n=29$; but *not* true when $n=41$, nor when $n=53$. This general theorem follows at once from Fermat's Theorem; for if $2n+1$ is a prime

$$\frac{10^{(2n+1)-1}-1}{2n+1}$$

is an integer;

$$\therefore \frac{(10^n-1)(10^n+1)}{2n+1}$$

is an integer; $\therefore$ either $10^n+1$ or $10^n-1$ is divisible by $2n+1$.]

6. Calculate in scale 11 the value to 30 places of undecimals of

$$\frac{tt,tt,t3}{tt,tt,t4} - \frac{tt,tt,t1}{tt,tt,t2}$$
$$\overline{tt,tt,t7} \quad \overline{tt,tt,t5}$$
$$tt,tt,t8 \quad tt,tt,t6$$

[The working in this question is, throughout, in scale 11.]

Let $x = 1000,000,000$, then the given expression is

$$\frac{\frac{x-8}{x-7}-\frac{x-t}{x-9}}{\frac{x-4}{x-3}-\frac{x-6}{x-5}} = \frac{(x-3)(x-5)}{(x-7)(x-9)} = \frac{x^2-8x+14}{x^2-15x+58}$$

$$= \frac{1-\frac{8}{x}+\frac{14}{x^2}}{1-\frac{15}{x}+\frac{58}{x^2}}$$

$$\begin{array}{r|l} & 1-8+14 \\ 15 & 15+107+t64+9368 \\ -58 & \quad -58-419-3872 \\ \hline & 1-8+73+646+55t6 \end{array}$$

= (by ordinary division) $1+\frac{8}{x}+\frac{73}{x^2}+\frac{646}{x^3}+\frac{55t6}{x^4}+\ldots\ldots$

Now $\frac{1}{x}$ contains 9 places of undecimals; $\therefore$ $\frac{55t6}{x^4}$ does not occur till the 33rd place.

Answer:

1.000,000,008,000,000,073,000,000,646,000,005,5t6,000,0.

And all the above 40 places of undecimals are correct.

7. If the sums of money in sixpences, shillings, and half-crowns are the same, the *number* of the coins must be in the ratio,

$\frac{1}{6} : \frac{1}{12} : \frac{1}{30}$; *i.e.*, 10 : 5 : 2

$\therefore$ $\frac{1}{17}$ths of the coins are sixpences, *i.e.*, 60;
$\frac{5}{17}$ths " " shillings, *i.e.*, 30;
$\frac{2}{17}$ths " " half-crowns, *i.e.*, 12;

60 sixpences = 30s. = £1 10s.

$\therefore$ The value of the bag is $3 \times$ £1 10s. = £4 10s.

8. £1,583 17s. 11d. in the 3 per cents. produces an income of $\frac{3}{100}${£1,583 17s. 11d.} = £47 10s. $4\frac{1}{20}$d.

£982 12s. 6d. in the $3\frac{1}{2}$ per cents. produces an income of $\frac{3\frac{1}{2}}{100}${£982 12s. 6d.} = £34 7s. $10\frac{1}{20}$d.

Hence the property in the 3 per cents. produces £13 2s. 6d. = £13·125 more income than does the property in the $3\frac{1}{2}$ per cents.

Now, if we take £1 from the 3 per cents., which is there producing an income of £·03, and transfer it to the $3\frac{1}{2}$ per cents., since we sell at 91 and buy at 98, we now obtain an income of $\frac{91}{98} \times \frac{3\frac{1}{2}}{100}$ = £·0325. Hence for every £ transferred from the 3 per cents. to the $3\frac{1}{2}$ per cents. we diminish the difference between the income from 3 per cents. and that from the $3\frac{1}{2}$ per cents. by £(·03 + ·0325) = £(·0625).

To diminish the difference by £(13·125) we must therefore sell out $\frac{13\cdot125}{\cdot0625}$ = £210, and we then have left

£1,583 17s. 11d. — £210 = £1,373 17s. 11d. Ans.

[The £210 sold out purchase £195 of $3\frac{1}{2}$ per cent., so that the property now is:

Three per cents. = £1,373 17s. 11d.
Three-and-half per cents. = £1,177 12s. 6d.

Income from either, £41 4s. $4\frac{1}{20}$.]

9. (1) ᔕ)10 ('13t

| | | |
|---|---|---|
| ᔕ | 13t. | Divide by 2. |
| 30 | ɛ5 | |
| 2t | 57 | |
| 90 | 289 | |
| 8t | 69 | |
| t | 84 | |
| | ɬ2 | |
| | ɬ1 | |
| | 3 | |

t. This remainder is one half of 10, and $\therefore$ the remainder of the process can be effected by division of 2 as indicated. Ans. ·13tɛ5ᔕ∞ɔ984ɬ2ɬ.

As a verification of the above, note that the result contains ɔ = ᔕ − 1 figures.

17)1 0 0 ('ɔ ɬ ɔ 5∞ t.

| | |
|---|---|
| ∞∞ | |
| 120 | |
| 11ᔕ | |
| 80 | ɔ ɬ ɔ 5∞ t |
| 6ᔕ | 7 8 2 ɔ 5 |
| 150 | 3 ɬ 1 9 ᔕ |
| 146 | ɛ ᔑ ɔ ɬ ɔ |
| ɬ0 | |
| ᔕt | |
| t | |

This being one-half of 10 we can now commence to divide by 2.

Ans. ɔ ɬ ɔ 5∞ t782ɔ53ɬ192ɛᔑ.

Noticing that $\frac{1}{17} = (\frac{1}{3})^3$, we may obtain this result more readily thus:—

$\frac{1}{3}$ = ·6ᔕ6ᔕ6ᔕ6ᔕ6ᔕ6ᔕ6ᔕ6ᔕ6ᔕ6. Divide by 3.
$\therefore \frac{1}{9}$ = ·24 8ᔑᔕɛ248ᔑᔕɛ2 48ᔑᔕɛ2. " "
$\therefore \frac{1}{17}$ = ɔ ɬ ɔ 5∞ t782ɔ53ɬ192ɛᔑ0...

9. (2) Convert 123456789tɛᔕ ᔕɬᔕɔᔑ∞ ɔ into scale 10.

We convert it by successive stages thus:—

123 = {1 × 20 + 2} × 20 + 3, etc.

The process is as follows:—

1
22
443
8864
177285
3545706
70914127
1418282548
28365650969
567313019390
11346260387811
226925207756232
4538504155124653
90770083102493074
1815401662049861495
36308033240997229916
726160664819944598337
14523213296398891966758
290464265927977839335179. Ans.

The ordinary method of successive division by 10 is peculiarly liable to error in Scale 20.

9. (3)

| | | |
|---|---|---|
| ·12ᔕɬ | = ·12ᔕɬ12ᔕɬ12ᔕɬ | 1 |
| ·56ᔑ | = ·56ᔑ56ᔑ56ᔑ56ᔑ | 5 |
| ·8ɔ | = ·8ɔ8ɔ8ɔ8ɔ8ɔ8ɔ | 8 |
| ·t | = ·ttttttttttt | t |
| | 1·5ɔt 979∞tᔑ∞01 | 4 |

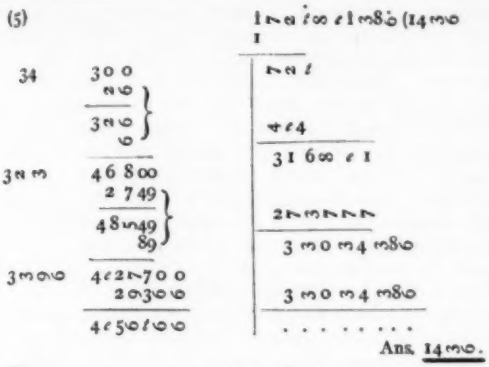
Ans. 1·5ɔt979∞tᔑ∞01.

9. (4)

| | |
|---|---|
| ·789tɛᔑ | |
| ·123ɬᔕ0 | |
| ·665ᔕᔕ0 | |

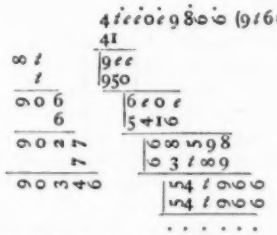
Ans. ·665ᔕᔕ0.

9. (5)

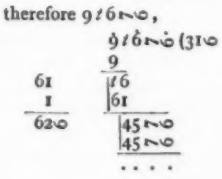


Ans. 1430.

9. (6)



Square root is therefore 9762,



Ans. 310.

10. It is well known and can be readily proved by pure arithmetic, that the hour hand and the minute hand of a clock point to the same figure at intervals of $65\frac{5}{11}$ minutes, *i.e.* at 1 h. $5\frac{5}{11}$; 2 h. $10\frac{10}{11}$; 3 h. $16\frac{4}{11}$; 4 h. $21\frac{9}{11}$; 5 h. $27\frac{3}{11}$; 6 h. $32\frac{8}{11}$; 7 h. $38\frac{2}{11}$; 8 h. $43\frac{7}{11}$; 9 h. $49\frac{1}{11}$; 10 h. $54\frac{6}{11}$; 12 h. 0. Now at these moments the second hand is pointing *respectively* to the minute spaces: $\frac{5}{11} \times 60 = 27\frac{3}{11}$; $\frac{10}{11} \times 60 = 54\frac{6}{11}$; $\frac{4}{11} \times 60 = 21\frac{9}{11}$; $\frac{9}{11} \times 60 = 49\frac{1}{11}$; $\frac{3}{11} \times 60 = 16\frac{4}{11}$; $\frac{8}{11} \times 60 = 43\frac{7}{11}$; $\frac{2}{11} \times 60 = 10\frac{10}{11}$; $\frac{7}{11} \times 60 = 38\frac{2}{11}$; $\frac{1}{11} \times 60 = 5\frac{5}{11}$; $\frac{6}{11} \times 60 = 32\frac{8}{11}$. Hence the second hand is only pointing to the same minute space as the two other hands at 12 o'clock.

The six hands of the two watches can therefore only be pointing to the same figure at 12 o'clock. When will this next occur?

At xii. mean solar noon Oct. 27th they are together;

At xii. mean solar noon Oct. 28th { 12h. 0′ 15″ } respectively.
they indicate - - - - { 11h. 59′ 45″ }

It is clear, therefore, that the hands will be together again at xii. after an interval of $\frac{12 \times 60 \times 60}{15}$ days. [N.B.—They will indicate the *same time* after $\frac{6 \times 60 \times 60}{15}$ days, *but* that time will be vi.], *i.e.* at mean solar noon 2,880 days later, *i.e.* at mean solar noon on September 16th, 1901. Ans.

The days in this question are thus distributed:—

| | | | | | |
|---|---|---|---|---|---|
| Mean noon Oct. 27th | to mean noon | Dec. 31st | 1893 | 65 |
| ,, Dec. 31st | 1893 | ,, | ,, | 1894 | 365 |
| ,, ,, | 1894 | ,, | ,, | 1895 | 365 |
| ,, ,, | 1895 | ,, | ,, | 1896 | 366 |
| ,, ,, | 1896 | ,, | ,, | 1897 | 365 |
| ,, ,, | 1897 | ,, | ,, | 1898 | 365 |
| ,, ,, | 1898 | ,, | ,, | 1899 | 365 |
| ,, ,, | 1899 | ,, | ,, | 1900* | 365 |
| ,, ,, | 1900 | ,, | Sept. 16th | 1901 | 259 |
| | | | | | 2,880 |

* *Not* a Leap Year.

Also since $2,880 = 7 \times 411 + 3$, and Oct. 27th is a Friday, it is clear that the day of the week is a Monday.

Ans. Monday, Sept. 16th 1901.

11. (This ingenious question is due to G. Osborn, Esq., M.A., of the Leys School, Cambridge.)

A certain interval in hour spaces separates the two hands when the time is 1.10..., and the same interval when the hands have moved into the new ambiguous position 2.5.... Between the two incidents the hour hand has moved through this interval; ∴ the minute hand has moved through (twelve times as much, and therefore through twelve such intervals, but it is now just this interval away from its former position, hence thirteen such intervals make up the complete circuit of the dial, *i.e.* 12 hour spaces; ∴ the interval between the hands when ambiguity occurs is $\frac{1}{12}$ of an hour space.

Now at 1 o'clock the minute hand is 1 hour space behind the hour hand. Between 1 o'clock and the required time it must therefore gain $1\frac{1}{12}$ hour spaces on the hour hand, but it gains 11 hour spaces per hour; ∴ it takes $\frac{1\frac{1}{12}}{11}$ hours to gain the required amount, *i.e.* $\frac{25}{132}$ hours, *i.e.* $10\frac{70}{143}$ minutes.

Hence the required time is $10\frac{70}{143}$ minutes past one.

The other possible time is readily found to be $5\frac{135}{143}$ minutes past two.

By precisely similar methods it can be shown that this occurs next at:

$15\frac{135}{143}$ minutes past 2; *or*

$11\frac{67}{143}$ ,, ,, 3.

We leave these as exercises for our readers.

12. Since 62·5 °/₀ of the gross receipts are working expenses;

∴ 37·5 ,, ,, ,, ,, ,, profit;

∴ $\frac{37 \cdot 5}{100}$ of the value of 100 tons = £52 10s.;

∴ £1 = the gold in $\frac{1}{52\frac{1}{2}} \times \frac{375}{1000} \times 100$ tons

$= \frac{\cdot 0011}{100} \times \frac{1}{52\frac{1}{2}} \times \frac{375}{10}$ tons of gold

$= \frac{11 \times 375 \times 2 \times 2240 \times 7000}{1000000 \times 105 \times 10}$ grains of gold

$= 123 \cdot 2$ grains.

[The actual weight of a sovereign is 123·274 grains, but of this only 113·001 is fine gold. The difference represents the profits of the Mint.]

13. The following is Lewis Carroll's (C. L. Dodgson's) own solution of his question [*Pillow Problems*, p. 53, published by Messrs. Macmillan].

On July 1 the watch gained on clock 5 m. in 10 h.; *i.e.* ½ m. per hour; *i.e.* 2 m. in 4 h. Hence when the watch said noon, clock said 12 h. 2 m.; *i.e.* clock was 3 m. slow of true time when *true* time was 12 h. 5 m.

On July 30 watch lost on clock 1 m. in 10 h.; *i.e.* 6″ per hour, *i.e.* 19″ in 3 h. 10 m. Hence when watch said 12 h. 10 m., clock said 12 h. 7 m. 19 secs.; *i.e.* clock was 2 m. 19 secs. fast of *true* time when true time was 12 h. 5 m.

Hence clock gains on true time 5 m. 19 secs. in 29 days, *i.e.* 319″ in 29 days, *i.e.* 11″ per day, *i.e.* $\frac{11}{24 \times 12}$ secs. in 5 m.

Hence while true time goes 5 m. clock goes 5 m. $\frac{11}{288}$ secs.

Now when true time is 12 h. 5 m. on July 31, clock is (2 m. 19 secs. + 11 secs.) fast of it; *i.e.* says 12 h. $7\frac{1}{2}$ m. Hence if true time be put 5 m. back, clock must be put 5 m. $\frac{11}{288}$ secs. back, *i.e.* must be put back to 12 h. 2 m. $29\frac{277}{288}$ secs.

Hence, on July 31st, when the clock indicates this time, it is true noon.

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THE Vere Foster Competition in Writing, Drawing, Painting, and Lettering, is an annual event of much interest to many thousands of Her Majesty's liege subjects in all parts of her dominions. Hence the publication of the report and the names of the successful competitors under this scheme is of much interest. Prizes to the value of £3,069 19s. have been awarded to the pupils of the 4,000 odd schools of all grades that have entered for this educational race. The arbiter was Mr. Foster himself, who has laid down the conditions that are to govern the 1895 contest. These can be had upon application to Messrs. Blackie, Old Bailey, E.C.

# ELEMENTARY LESSONS IN AGRICULTURAL ZOOLOGY.

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## INTRODUCTORY REMARKS.

THE unfortunate condition of Agriculture in the United Kingdom which has existed now for some years, and which seems to offer but little hope of improvement upon purely commercial lines, has excited a wide-spread interest among all thinking men. Whatever be the methods adopted by the cultivators of the soil, good in some quarters but sadly empirical in most cases, the fact remains that agriculture is one of the most important industries of the land. In the hope of reviving it, scientific men have for some time been turning their attention to the task of inculcating the principles upon which the cultivation of the soil is based, and the question of agricultural education is now a burning one. Not only has the Science and Art Department lent its aid, but the leading Universities have taken the matter up. Oxford has just appointed a new professor of Rural Economy to carry on the work now relinquished by Sir Henry Gilbert; Edinburgh has the subject under the charge of Professor Wallace; and Cambridge has instituted a scheme in which many workers co-operate, and on the results of examinations under it, partly theoretical and partly practical, diplomas are awarded. Of the provincial colleges, Bangor has established an agricultural department, which has so far been very successful. The County Councils of the various agricultural counties have taken up the matter heartily, some endowing local colleges, as at Reading; others supporting various lecturers and teachers who travel through the country, lecturing at different centres. The question of scientific education as applied to Agriculture is thus one of great importance. Many subjects of scientific interest are bound up with this great industry, and it is hoped that on that account this new series of articles on a branch of Zoology may be of value to the student.

## CHAPTER I.—CARNIVORA.

In considering the relation of Zoology to Agriculture, we shall only be concerned with five of the seven sub-kingdoms into which the animal kingdom is divided.

The first of these, the Vertebrata, is so called from the fact that its members possess a vertebral column or backbone, associated with which are two girdles of bones to each of which two limbs are attached, making up the whole bony framework or skeleton of the body. The body as a whole consists of head, trunk, and limbs, the two former containing cavities in which the various organs of life are deposited. Vertebrate animals are capable of being divided into exactly similar halves by a plane of division passing vertically downwards through the head and trunk, or to use a technical expression, they are *bilaterally symmetrical*. The vertebral column is sometimes called the spine. It consists of a varying number of flattened bones provided with curious processes and perforated by a central cavity. The holes in the successive bones correspond in position with each other, so that the whole axis contains a long narrow chamber, in which is found the spinal marrow. The cavity is continued upwards into the large cavity of the skull, and the contents are continuous with the substance of the brain, which is contained in the latter, the whole composing what is known as the central nervous system. As the vertebral column is the backbone, this nervous system lies on the dorsal side of the animal. Besides this so-called neural canal, the trunk contains a cavity in front or on the *ventral* side. This is only partly formed of bone, a number of somewhat flattened ribs extending round its upper part, and being connected with the backbone behind and with another bone, the breast bone, in front. The lower part is not so protected, its walls being formed mainly of muscles. In the higher vertebrates these two parts of the cavity of the trunk are separated from each other by a partition called the diaphragm, and compose the *thorax* or chest, and the *abdomen* or belly. In the chest are situated the heart and lungs, in the abdomen the organs of digestion and excretion. The structure of the heart varies in the different groups. Essentially it consists of two parts, one to receive the blood brought back by the veins from the other parts of the body, the other to force it again through the arteries. Different arrangements are found in the several groups, securing the circulation of the blood and its continual purification.

The vertebrate sub-kingdom embraces five classes, Mammals, Birds, Reptiles, Amphibians, and Fishes.

The first class of the Vertebrata is known scientifically as the *Mammalia*. The members composing this class are so called because they suckle their young, which are produced alive. In this group we have always the division of the trunk cavity into thorax and abdomen, the presence of the diaphragm being constant. The heart consists of four chambers, which are found to be so arranged that the two on the right side communicate with each other directly, as do those on the left, but the cavities of the two sides are completely separated from each other. The blood is propelled from the right side of the heart to the lungs, and from the left side to the other organs and parts of the body. The two streams, the arterial and the venous, never mix, as they do in the lower vertebrates.

The orders of Mammalia that are of agricultural importance are few in number, comprising *Carnivora* (beasts of prey), *Insectivora* (insect-eaters), *Cheiroptera* (bats), *Rodentia* (gnawing animals), *Ruminantia* (cud-chewing animals), *Pachydermata* (thick-skinned animals), and *Solidungula* (single-hoofed animals).

The *Carnivora* are thick-skinned, powerful beasts of prey, endowed with keen sight and scent, and capable of moving with great rapidity. As a rule their heads are broad, in consequence of the strong development of their chewing muscles, and in some of the families of this order the claws are very sharp. The lower jaw is smaller than the upper jaw, and can move only up and down, an arrangement that makes the extremely sharp teeth divide anything that comes between them very much as if they were a pair of shears. We can only notice here *Canidae*, the dog family, and *Mustelidae*, the weasel family.

The members of the dog family that are most important to the farmer are the dog and the fox. Since

dogs generally pursue their prey in large bands, their limbs are formed more for rapid motion than for strength. They possess in a high degree the power of endurance. Wild dogs have been known to pursue and kill the tiger itself. The claws of the dog are strong and blunt, constituted rather for running and digging than for capturing his prey. They have no sheaths like those of the cat, and unlike them cannot be drawn back, *i.e.*, they are not retractile. All dogs possess in a high degree the sense of smell, especially the various hounds used for hunting. It is unnecessary to enlarge on the services of the sheep-dog to the farmer.

The fox, *Canis vulpes*, bears a general resemblance in appearance to a small lurcher dog, for which it has sometimes been mistaken by superficial observers, but there are several points of difference. The dog has a large ball to the heel of his foot; the fox has hardly any ball to his foot. The pupils of the eye in the dog are round; those of the fox are elliptic, like the eye-pupils of the cat. A great observer and lover of animals, the late Frank Buckland, once noticed a fox wag his brush like a dog wags his tail to show his pleasure; but this fox was an inmate of the Edinburgh Zoological Gardens, not a wild fox. The fox lives always in an underground dwelling, sometimes dug out by itself, but in many cases a deserted badger burrow. Its services to the farmer and the damage it does him seem to be pretty evenly balanced. It is a ruthless foe to roes, fawns, hares, and game-birds, and every farmer's wife deplores its ravages among her poultry yard. On the other hand, the fear of betraying its hiding-place prevents its committing ravages in the neighbourhood of its burrow, and it catches enormous numbers of field-voles and rabbits. It also eats cockchafers, worms, and slugs, which, as we shall see, are great enemies of the farmer's crops.

The *Mustelidae*, or Weasel family, are easily recognised, the long slender body and short limbs making its members very noticeable. Their bodies, like those of dogs and foxes, are modified in form, so as to aid in their pursuit of living prey. The head is small and flat, and the skull is elongated. The tongue is smooth. Each foot has five toes, and the sharp, small, powerful claws readily enable them to ascend the trunks of trees in search of their prey among the branches, for the shortness of their legs makes them capable of inserting their sharp claws into every little crevice in the bark. The slenderness and litheness of their bodies fit them for tracking to their homes various small animals that burrow in the earth. They have much muscular power in proportion to their size, and are endowed with a great deal of courage and perseverance. The offensive odour possessed by weasels is due to the presence of stink glands situated near the tail. The members of this family, injurious in one way or another to the farmer, are the pine marten, the beech or stone marten, the pole-cat, the ferret, the stoat, the weasel, the otter, and the badger.

The pine marten, *Mustela martes*, and the beech or stone marten, *Mustela foina*, are about the same size, the body being about 20 inches long, and the tail about half the length of the body. The fur of the pine marten is brown with yellowish woolly hairs, and there is a yellow patch on the throat. That of the beech or stone marten is greyish brown with whitish woolly hairs, and there is a white patch on the throat. The pine marten makes its home in the shelter of thick woods, where it preys upon small birds and squirrels. It also kills large quantities of game and poultry. The beech or stone marten is chiefly found in the near neighbourhood of human dwellings, choosing for its home barns, wood-stacks, etc. It is a great enemy of the poultry yard, but will also eat wild birds, mice, and game.

The polecat, *Putorius foetidus*, is rather smaller than the martens; its tail is shorter and its hair is not so long. In the summer it is rather a friend than a foe to the farmer, living as it does in the open country, in hollow holes or in the burrows of foxes and rabbits, and destroying numerous field-voles, water-rats, etc. In the winter it changes its method of life, settling down near human dwellings, and choosing for its home heaps of brushwood, hay-lofts, etc. Then it attacks the fowl-house and the dovecot, killing the birds and devouring the eggs, which it sucks without smashing them. It is fond of honey too, and in winter lays the beehives under contribution.

The ferret, *Putorius furo*, is a short-legged variety of the polecat, which is usually white in colour and has red eyes. Its capacity of being trained to follow rabbits and rats into their holes and drive them out and kill them, makes it one of the farmer's friends.

The stoat, or ermine, *Putorius erminea*, is only about 12 inches long. Its tail is about a quarter the length of its body, and its body is very little broader than its head. Its appearance varies very much with the season, its summer fur being of a warm cinnamon brown above and white below, while its winter fur is white. The tip of the tail is black all the year round, but the rest of it is cinnamon in summer, white in winter. The stoat lives mostly in fields in the neighbourhood of woods and plantations, and is always to be found among sandhills, owing to the number of rabbits there on which it feeds. Though it is often very destructive in dovecots and hen-houses, the stoat is of considerable service to the farmer, destroying as it does mice, rats, rabbits, and hares.

The weasel, *Putorius vulgaris*, is smaller than the stoat. Its trunk is so slender that it is almost snake-like. This extremely alert, sharp little animal can easily pass along mouse-holes. Unlike the stoat, its summer and winter coats do not vary, the back being brown and the belly white. Though the weasel is destructive to game and does a certain amount of damage to fowl-house and dovecot, it must be considered one of the most untiring friends of the farmer. So varied is its food, that, although it is fondest of field-voles, it also attacks rats and water-rats, young hares and rabbits, and birds that build near the ground, and their eggs, which it carries home under its chin. It will also occasionally eat lizards, blind-worms, snakes, and frogs. Where there is a plague of voles, the usual breeding season which takes place in spring is followed by another further on, and it is noticeable that wherever a district becomes infested by voles an immigration of weasels from the neighbouring districts takes place. The weasel is as useful in winter as in summer, even following under the snow the voles which winter in the country.

The otter, *Lutra vulgaris*, is one of the largest of the weasel tribe, the length of its body being usually

from 28 to 32 inches, and of the tail from 14 to 16 inches. Frank Buckland once had sent him an otter measuring 4 feet 3 inches from the tip of the nose to the end of the tail, which was 15 inches long. But this was a giant of the tribe. The otter has a smooth skin of a shining dark brown colour, both above and below, and the head, which is wedge-like, has a rounded snout, near which on both sides are a great number of whiskers, each of which is associated with a bunch of nerve substance, and connected by means of another nerve with the brain. By means of these whiskers the otter, which is a water animal, is enabled to guide his movements. The short legs with their webbed toes are adapted for swimming. The otter does not use his fore and hind legs for this purpose, but folding his front paws alongside his body, strikes out vehemently with his two hind legs. He thus darts along with a series of rapid jerks. His hind feet are much longer than his fore feet. When hunting under water, the otter seems to be guided more by sight than by his sense of smell. He keeps his very prominent rat-like eyes wide open all the time, and though they are excessively small, they do him good service. He carries his flat tail, which is, however, pointed at the tip, in such a way as to guide himself, and by its means can turn very quickly in and out among the sunken roots of water-side trees. The canine teeth of the otter are conical, and serve him almost as scissors. When he catches a fish, he sticks his sharp canines immediately through its head, and waits till it is dead. He never uses them for eating his prey, but bites at the fish with the side of the mouth only. Since the gullet, instead of being a large dilatable tube as in most fish-eating creatures, is a very small tube, if the otter did not cut up his food very small he would be choked. The main food of the otter is fish. It is found on the banks of lakes, pools, ponds, rivers, brooks, etc., in fact wherever fish is plentiful. It preys also on the farmer's ducks and geese, and their young, and catches water-rats, wild duck, water-birds, frogs, cray-fish, and water insects. In Wales the otter is called the water-dog, and a French sportsman, Monsieur d'Houdetot, has termed him the 'wolf of the river.' The young of the otter are laid up by the mother in a burrow excavated under the roots in a bank at the water's edge.

The badger, *Meles taxus*, is one of the largest of the weasel family, its heavy body being 3 feet in length, and weighing from 22 to 33 pounds. Its fur, which is rather long, is of a yellowish whitey grey colour, mixed with black. While the head is striped longitudinally with black and white, the short tail, like the body, is of a yellowish grey. The legs of the badger are short, and the toes have strong digging claws. The burrow of the badger is a very extensive one, several passages, the openings of which may be as far apart as ninety-seven feet, leading to the exterior. In this dwelling the badger stays till the evening. Its digging habits are somewhat destructive, causing it to throw up young trees and other plants by the roots, but it is the occasion of considerable benefit as well as injury to the farmer, for its food, which is very varied in its nature, includes many of the foes of his crops. It eats mice, birds that nest on the ground—especially attacking the eggs and young—frogs, cockchafer grubs, earth-worms, and insects. It is also fond of turnips, carrots, acorns, and sweet fruits. Though the badger does not hibernate, it often sleeps several days in succession during the winter.

To recapitulate, we have seen that:—

1. The great Vertebral sub-kingdom derives its name of *Vertebrata* from the fact of its members possessing a vertebral column or backbone. They are bilaterally symmetrical.

2. The first class of the Vertebrata, known technically as the *Mammalia*, is so called because its members suckle their young, which are produced alive.

3. The order of Mammalia called *Carnivora* consists of thick-skinned, powerful beasts of prey endowed with keen sight and scent, and possessed of very sharp teeth and claws.

4. The members of *Canidae*, the dog family, that are of importance to the farmer are the fox, *Canis vulpes*, and the dog.

5. The members of *Mustelidae*, the weasel family, are clearly recognised by means of their long slender body and short limbs. They comprise the pine marten, *Mustela martes;* the beech or stone marten, *M. foina;* the polecat, *Putorius foetidus;* the ferret, *P. furo;* the stoat or ermine, *P. erminea;* the weasel, *P. vulgaris;* the otter, *Lutra vulgaris*, and the badger, *Meles taxus*.

## TEACHERS' DRAWING LESSONS.

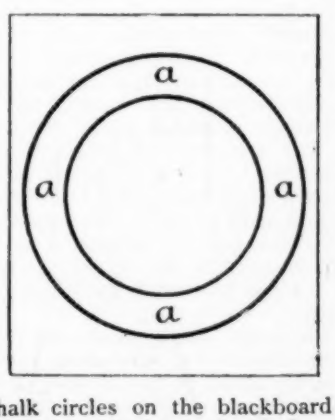
### MODEL.

### Standard VI.

BY E. BUFFERY RIDGE,
*Art Master under the London School Board.*

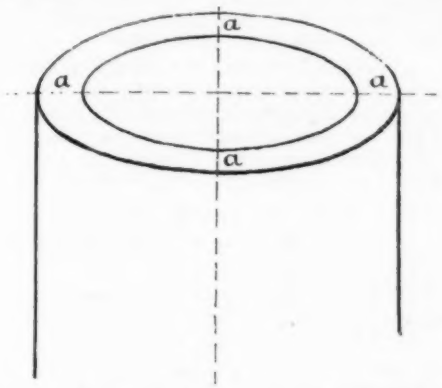
*Rims*, or *edges*, of vases, basins, &c., should be carefully studied. Most of them may be regarded as either *flat*, *upright*, or *round*.

*Flat Rims.*—An ordinary drain-pipe of circular section supplies a good example. Each end has two concentric circles, the space between them being flat.



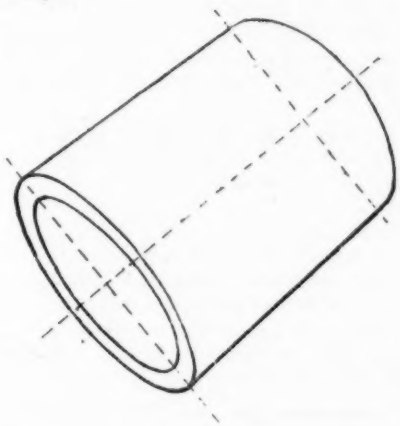

Draw chalk circles on the blackboard with the compasses, about 12 inches and 9 inches radii, and place the board in a horizontal position as in the previous lesson. The space *a*, *a*, is 3 inches wide all

round, but appears much narrower at the front and the back than at the two ends.

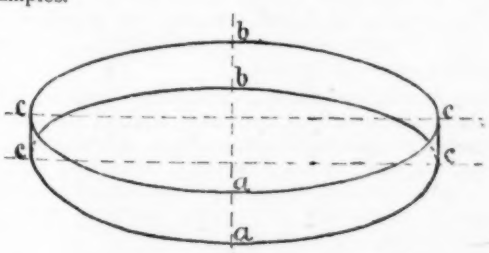



The end of the drain-pipe gives a similar figure, *i.e.* two ellipses with the same proportions and the same centre. The sides are parallel in the first sketch (upright) and vanishing in the second.

The plaster cast of bowl and sphere shows another good example.



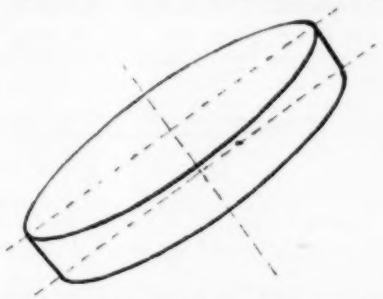
*Upright Rims.*—The tire of a cart-wheel, an iron hoop from a barrel, a leather belt, a strip of paper or cardboard fastened to form a circle, will furnish examples.




Some sets of models include a flat cylinder or cheese-shaped figure, the circumference of which is a curved surface similar to those seen in the articles mentioned above.

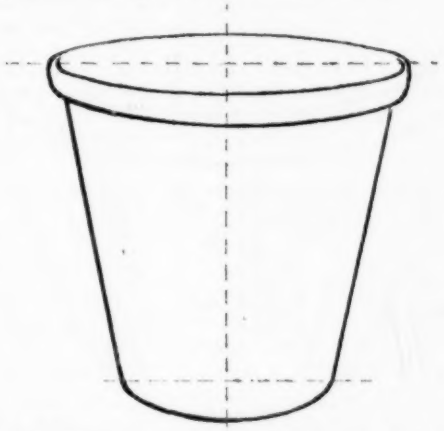
The two circles are one above the other, not in the same plane, and therefore have not a common centre.

The lower ellipse will be somewhat wider than the upper, as in cylinders generally, so that the space between the two curves will be widest in front *aa*,



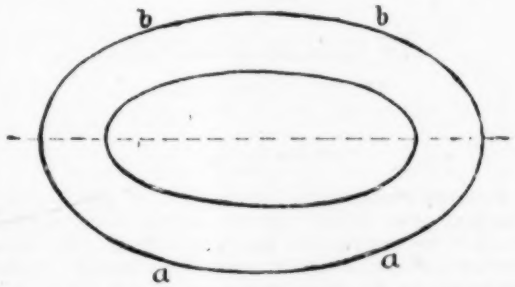
narrowest at back *bb*, and between these two at the sides *cc*, *cc*. The curvature of the ellipses makes them appear to narrow the space between them at the ends (*c*,*c*,)more than is actually the case.

Again, notice *parallel* vertical sides in the upright band, and *vanishing* in the inclined cheese.



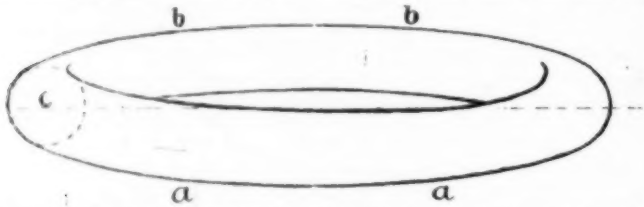
*Round Rims.*—A piece of thick rope or tubing placed so as to form a circle, a large iron ring, or a wooden curtain-ring if nothing larger can be had.

Two elliptical curves will be seen, the centres practically the same and the space between the curves widest in front, and gradually decreasing to the back. Notice particularly that the part of the

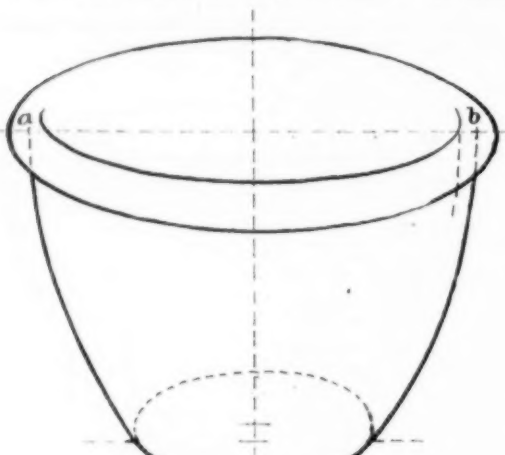



curve *aa* is the bottom outline of the figure, while *bb* is part of the top outline, but they are made continuous at the ends by the curvature of the model itself. The same effect is produced in the inner curve when in such a position as is shown in the first sketch, but not when seen at a smaller angle. Then the top

outline in front fades away at the ends of the inner curve, and is replaced by the portion of the bottom outline, if any, seen at the back. This is shown in the second sketch. The shape and size of the section of the ring must be kept in mind when drawing the ends, as at *c*.




In sketching the basin, make allowance for the thickness of the material at *a* and *b*. Notice how the sides, when produced, will meet at *c* in the centre line, and how the cone-shaped form of the basin




allows much less than half of the bottom ellipse to be seen. The same points may be looked for in the flowerpot, but the rougher manufacture makes them less perceptible.

## NEW PROBLEMS IN ARITHMETIC.

BY T. B. ELLERY, F.R.G.S.,
*Vice-President National Union of Teachers.*

5TH PAPER.

For introduction, *see* October No. of *The Practical Teacher*. For other remarks on the same subject I refer my readers to the *Girls' Mistress* for September 1st last, in which appears the first of a series of papers on *Standard Problems for Girls, and How to Solve them*. In passing let me say:—

1. Every exercise here given will suggest to the practical teacher many others of the same kind.
2. The blackboard should be freely used in the solution of these problems.

As several of these exercises are based on problems set by the Education Department and other examining bodies, this Paper will be found of great service, not only in blackboard lessons to Standard 7, but also in pupil teachers' examinations. Candidates for the College of Preceptors Examinations, Oxford and Cambridge Local, Queen's Scholarship, etc., will also do well to work out every one of the Problems in this Paper.

A.

1. I buy articles at 3 for 2d., and sell at the rate of 5 for 4d. Find my gain per cent.

2. I lend £400 at 3 per cent. per annum, £300 at $2\frac{1}{2}$ per cent., £650 at $2\frac{1}{4}$ per cent., and £150 at 4 per cent. Find my average rate of interest.

3. Divide £1,303 11s. 6d. among 3 persons so that their respective shares shall be as $3\frac{1}{2}$, $4\frac{1}{2}$, 6.

4. A fox, with a quarter of a mile start, is pursued by a hound which runs 12 feet while the fox runs 10. What fraction of two miles must the hound run before he catches the fox?

5. A lends money to B, and receives as interest every month $\frac{1}{36}$ of the amount lent. What is his rate of interest per cent. per annum?

6. After spending $\frac{1}{3}$ of $\frac{2}{5}$ of $\frac{9}{10}$ of my money, I have enough left to buy ·25 of ·75 of 176 oranges at 3 for 2d. What had I at first?

7. A sells an article to B, gaining 20 per cent. on what he gave for it. B sells it to C, gaining 10 per cent. on what he paid for it. C paid £11. What did A pay?

8. A man puts his money into four successive ventures. In the first he loses 25 per cent., and in each of the others he gains 20 per cent. What percentage of profit remains on his original outlay?

9. A man sells goods for a guinea by which he clears $\frac{2}{5}$ of the cost price. Find his gain per cent. if he sell them for a sovereign.

10. A school is open ten times in a week. 120 children make an average of 8·75 times per child during the week. 90 of these children make an average of 9·5 times per child. What is the average of the remainder?

11. A merchant bought wines at 30s., 32s., and 37s. per dozen, and mixed them in the proportion of 5, 3, 2. He then sold the mixture at 40s. per dozen. Find his gain per cent.

12. A cricketer bats in 30 innings and is out on each occasion. In 25 of these innings he had an average of 28 runs per innings. He then made 64, 100, 0, and 28 respectively. In his last innings he made a certain number of runs which made his average 32 for the year. How many runs did he make on the last occasion?

B.

13. A train has 1st, 2nd, and 3rd class passengers in the proportion of 1 : 4 : 9. The total number of passengers is 378. How many are there of each class?

14. Divide £11 among A, B, C, so that A's share may be $\frac{7}{9}$ of B's, and B's $1\frac{1}{2}$ of C's.

15. A, B, and C are engaged to do a certain piece of work. By himself A could do the work in 4 days, B in 6 days, and C in 8 days. What fraction of the work would they, working together, perform in 8 hours, the working day being reckoned at 12 hours?

16. If 25 oranges be worth 40 buns, and 17 buns be worth $8\frac{1}{2}$ lb. sugar, what is the value of 40 oranges when sugar is 2d. a lb.?

17. X can do a piece of work in 4 days, Y in 3 days, and Z in 2 days. X and Y work together for half a day, and Z is left to finish the work alone. In what time will Z finish it?

18. I own $\frac{1}{3}$ of a business worth £6,000 and my brother $\frac{1}{5}$ of the remainder. What should a person pay us altogether for our shares so that he may make a profit of $6\frac{2}{3}$ per cent. on his investment?

19. What sum must I invest in the $95\frac{3}{4}$ per cents. at $3\frac{1}{8}$ (brokerage $\frac{1}{8}$) to bring me an annual income similar to that which a friend derives from £5,000 stock which he holds in the $2\frac{1}{4}$ per cents. at 98?

20. I invest £30,000 in the $2\frac{1}{2}$ per cents. at $93\frac{5}{8}$ (brokerage $\frac{1}{8}$). What will be my income after deducting income tax at 8d. in the £?

21. What sum must I invest in the $2\frac{1}{2}$ per cents. at $95\frac{7}{8}$ to obtain an income of £580, after payment of income tax at 8d. in the £, brokerage being $\frac{1}{8}$?

22. A's income is two-thirds of B's, and together A and B pay $£42\frac{7}{12}$ income tax at 8d. in the £. What is the income of each?

23. 8 men, or 16 women, or 20 children, can do a piece of work in 41 hours. How long would 3 men, 4 women, and 8 children take to do it?

24. Two men ride from one town to another on bicycles. One covers 12 miles an hour, and the other 9 miles an hour, and the former reaches his journey's end 45 minutes before the other. What is the distance between the two towns?

## C.

25. A bookseller buys books at 3s. 3d. each, receiving 13 copies for the price of 12. He sells the 13 copies at 5s. each. Find his gain per cent.

26. What will it cost to carpet a room 36 feet long and 18 feet broad with carpet $\frac{3}{4}$ yard wide at 3s. 11d. a yard?

27. Two men bought equal stocks of buns which they sold at a penny each. One gave 4d. for 6 buns. The other gave 6d. for 8 buns, and thereby made a shilling less profit than the former. How many did each buy?

28. A train consists of engine, tender, and 12 carriages. The weight of the engine and tender equals $\frac{7}{17}$ of the total weight of the train, and is 100 tons less than the weight of the carriages. Find the weight of a carriage.

29. Equal quantities of tea, which cost 2s. 4d. and 1s. 6d. per lb. respectively, are mixed and sold for 2s. 3d. per lb., at a total profit of $£3\frac{1}{3}$. How many pounds are sold?

30. Large needles cost 1d. per dozen more than small needles. A girl who buys equal quantities of both finds that on the whole she gets 4 for a penny. What is the price per dozen of each kind?

31. A woman sells eggs at 1s. 8d. a dozen, and gains 20 per cent. How many must she sell for a sovereign to gain 28 per cent.?

32. A and B can do half of a piece of work in 6 days. B alone finishes it in 9 days. How long would it have taken A to finish it?

33. Divide fifteen guineas between X and Y so that ·25 of X's share shall equal ·375 of Y's.

34. 18 men and 8 boys are employed in a factory. A man's wages are $2\frac{1}{2}$ times those of a boy, and in a week of 6 days the total wages paid amount to £22 10s. Find the daily wages of each man.

35. A tithe rent of £560 per annum is commuted in equal parts into a corn rent of wheat at the average price of 42s. per quarter, and barley at the average price of 35s. per quarter. What will be its value when the average price of wheat falls 6s. per quarter and barley rises 1s. per quarter?

36. A man invested equal sums in a 4 per cent. stock at 84 and a $3\frac{1}{2}$ per cent. at 77, and at the end of a year he found that the difference in his income from the two investments was £100. What sum was invested in each stock?

37. I buy 20 shares of £25 each at £30. After receiving a dividend of $12\frac{1}{2}$ per cent., I sell out at $£35\frac{1}{2}$. Find my total gain.

38. X can do a piece of work in $3\frac{1}{3}$ days, Y in 5 days, and Z in 4 days. X and Y work together for 2 hours, and then Z assists. How long will Z be at work before the task is completed? (Reckon 8 hours to the day.)

39. Two wines worth 30s. and 25s. per gallon respectively are mixed. If the mixture be worth 26s. 8d. per gallon, in what ratio are they mixed?

40. A man rows from X to Y, a distance of $22\frac{1}{2}$ miles, and back in still water in 9 hours. How long would he take to row the same distance if a stream flow from X to Y at the rate of $2\frac{1}{2}$ miles an hour?

ANSWERS.

(1) 20 per cent.
(2) $2\frac{2}{19}$ per cent.
(3) £325 17s. 10½d.; £419 0s. 1½d.; £558 13s. 6d.
(4) $\frac{3}{4}$.
(5) $33\frac{1}{3}$ per cent.
(6) 2s. 1d.
(7) £8 6s. 8d.
(8) $29\frac{2}{7}$ per cent.
(9) $33\frac{1}{3}$ per cent.
(10) 6·5 times.
(11) 25 per cent.
(12) 68 runs.
(13) 1st 27; 2nd 108; 3rd 243.
(14) A £3 10s.; B £4 10s.; C £3.
(15) $\frac{12}{13}$.
(16) 5s. 4d.
(17) $1\frac{5}{13}$ day.
(18) £2,625.
(19) £3,247.
(20) £773 6s. 8d.
(21) £23,040.
(22) A £511; B £766 10s.
(23) 40 hours.
(24) 27 miles.
(25) $66\frac{2}{3}$ per cent.
(26) £21 3s.
(27) 144 buns.
(28) $14\frac{1}{2}$ tons.
(29) 200 lb.
(30) 2½d. and 3½d.
(31) 135 eggs.
(32) 18 days.
(33) X £9 9s.; Y £6 6s.
(34) Man, 3s. 6d.
(35) £528.
(36) £46,200.
(37) £172 10s.
(38) $1\frac{1}{8}$ day, *or* 9 hours 20 minutes.
(39) 1 : 2.
(40) 12 hours.

# OUR PUPIL TEACHERS' COURSE.

BY GEORGE COLLAR, B.A., B.SC.,
*Head Master of Stockwell Pupil Teachers' School, London.*

## SCHEME OF WORK FOR THE MONTH.

### A.—*English.*

(i.) *First Year.*
Completion of the predicate—objects, direct and indirect complements. Examples in Analysis.
See Morris, p. 112; Daniel, 131–135; Beach, 125.

(ii.) *Second and Third Years.*
Figures of speech, preparatory to study of paraphrase. See Beach, pp. 163, 164.
Examples in Analysis.

### B.—*Arithmetic.*

(i.) *First Year.—Boys.*—Multiplication and Division of Fractions. C. Smith, pp 92–99; Macmillan's 'Arithmetic for the Standards,' VII., pp. 3–9; Lock, pp. 97–103; Pendlebury, pp. 100–105.

*Girls.*—Bills of Parcels. See Macmillan's 'Arithmetic for the Standards,' V., pp. 28–32; Pendlebury, 181–184; Lock, pp. 146–148; Dixon and Beach, pp. 67–71.

(ii.) *Second Year.—Boys.*—Averages. 'Arithmetic for Standards' contains some excellent examples. See VII., pp. 1–7.

*Girls.*—Same as First Year Boys.

(iii.) *Third Year.—Boys.*—Revision of Compound Rules, Reduction. Particular attention must be paid to the *methods of teaching* these rules.

*Girls.*—Recurring Decimals, exact signification of the recurring period. Reduction of recurring decimals to vulgar fractions,—proof of the rule. Addition and Subtraction of Recurring Decimals, *without* reduction to vulgar fractions. See Lock, pp. 149–153; Dixon and Beach, pp. 102–110; C. Smith, pp. 124–130; Pendlebury, pp. 136–142.

### C.—*Euclid.*

(i.) *First and Second Years and Third Year Girls.*—To end of Proposition XVII.

(ii.) *Third Year.—Boys.*—To end of Book I.

### D.—*Algebra.*

(i.) *First and Second Years and Third Year Girls.*—To end of Division.

(ii.) *Third Year.—Boys.*—Results in Multiplication, Factors.

### E.—*Mensuration.*

General exercises on rectangles and triangles.

### F.—*Teaching.*

(i.) *Second Year.*—Flux's 'School Management,' Ch. III.

(ii.) *Third Year.*—Flux's 'School Management,' Ch. VIII.

### G.—*Geography.*

General Geography of British North America.

### H.—*History.*

To death of Stephen.

## TEST QUESTIONS ON LAST MONTH'S WORK.

*First Year.*—1. Explain the meaning of the terms—Verb of Incomplete Predication, Transitive Verb, Impersonal Verb.

2. Why is it necessary to bring fractions to the same denominator when they are added or subtracted?

3. Find by Practice the weight of 47 c. yds. 12 c. ft. of timber if 1 cubic yd. weighs 9 cwt. 2 qrs. 16 lbs.

*Second Year.*—1. Explain what is meant by the Nominative Absolute; when is it used?

2. What is the meaning of 'per cent'? How much per cent. is 3 qrs. 17 lbs. of 4 cwt. 2 qrs. 1 lb.?

3. Find the value of $3\frac{1}{3} + 2\frac{1}{5} - 1\frac{1}{3} + \frac{2}{5} - \frac{7}{15}$.

4. Explain clearly the difference between 'induction' and 'deduction.'

*Third Year.*—1. Give a list of the suffixes of Greek origin which are used to form nouns.

2. Divide 783264 by 35, using factors, and explain how you obtain the correct remainder.

3. Find the area of a triangle whose sides are 15, 36, and 39 ft. in length.

4. State the rule for Division of Fractions, and say what illustrations you would employ in teaching it to a class.

*All Years.*—1. Compare the physical features of the eastern part of Ireland with those of the western part.

2. What do you know of the following:—Drogheda, Slieve Donard, Kenmare River, Limerick, Waterford, Giant's Causeway?

3. Give a short account of the principal industries of Ireland.

4. Which of the kings before the Conquest were not succeeded by their eldest sons? How was the succession determined?

5. Write a life of Godwin or Dunstan.

6. What traces now remain of the settlement of the Danes.

## HINTS ON LAST MONTH'S QUESTIONS.

*First Year.*—2. 'It am I' is incorrect; we should say 'It is I,' because although '*I*' is one of the nominatives of the verb, it is not the nominative of the subject, but of the complement, and the verb must agree with the *nominative of the subject*, and as '*It*' is in the 3rd person, the verb must be in the 3rd person also.

'You *were* there,' not *was*. The pronoun *you* is always plural.

We say 'Either John *or* I *was* there,' but 'John *and* I *were* there,' because when two singular words are joined by *or* the verb only applies to *one* of them and not to *both*, consequently it must be in the singular; but when two singular words are joined by *and*, they are equivalent to a plural word, consequently the verb must be in the plural.

'A row of books *is* on the shelf.' Here the subject contains a singular and a plural word, but the singular word is the *nominative*.

*Second Year.*—1. (*a*) I know *where the violets grow* (noun).
(*b*) I have been to the wood *where the violets grow* (adjective).
(*c*) It is pleasant to ramble *where the violets grow* (adverbial).

4. A compound ratio is one obtained by multiplying two or more ratios together. The question therefore is—By what must $\frac{6}{11}$ be multiplied to produce $\frac{13}{22}$?

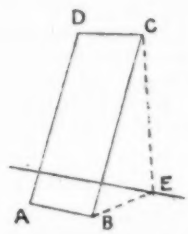
$$\frac{13}{22} \div \frac{6}{11} = \frac{13}{12}. \quad \text{Ans.}$$

5. The first vessel contained $\frac{5}{11}$ pints of milk and $\frac{6}{11}$ pints of water; the second contained $\frac{2}{3}$ pints of milk and $\frac{3}{5}$ pints of water. Consequently when the two are mixed there are $(\frac{5}{11} + \frac{2}{3})$ pints of milk to $(\frac{6}{11} + \frac{3}{5})$ pints of water; that is, $\frac{47}{33}$ to $\frac{63}{55}$, or 47 : 63.

*Third Year.*—2. *De*-bar, a hybrid word, *de* Lat. = from, and Celtic (through the French) *bar*; *de*-scribe, Lat. *de* = down; *de*-vil, Greek *dia* = through. *By*-law, *by* is Danish for town, a *by*-law is a law of local effect; *by*-stander, English, a stander *by*. *Dis*-tance, Lat. *dis*, apart; *di*-orama, Gr. *dia* = through; *di*-lemma, *di* = two. *Un*-til, Eng. = *even* till (till being Scandinavian); *un*-lock, un before verbs is English, and implies a reversal of the action; *un*-steady, Eng., *un* = not; *un*-animous, Lat. *unus* = one.

4. Extract the square root.

*Mensuration.*—1.




BE = 20 inches, CE = 48 inches,
$\therefore$ CB = $\sqrt{20^2 + 48^2}$ = 52 inches.
$\therefore$ Area of blackboard = (52 × 34) sq. inches.
= $\frac{1768}{144}$ sq. ft. = 12 sq. ft. 40 sq. in.

## SCHOLARSHIP—FOURTH YEAR.

### *Work for February.*

*English.*—Literature, 1553 to 1603, omitting the drama. Detailed study of the verb.

*Arithmetic.*—Simple Interest. To find Interest, Amount, Principal, Rate, or Time, when three other terms are given.

*Algebra.*—Simple equations (one or more unknowns).

*Mathematics.—Girls.*—See First Year Boys.

*Geography.*—General Geography of Scandinavia, Denmark, Holland, and Belgium. Map of New Zealand.

*History.*—To accession of Edward I.; special attention to be paid to Constitutional History.

*School Management.*—Flux, Ch. VI.

*Domestic Economy.*—Conduction and Radiation of heat. Dress in relation (*a*) to cleanliness, (*b*) to warmth, (*c*) to appearance, (*d*) to cost.

*Music.*—Simple and Compound time, both duple and triple.

**Model answers to the questions set at the recent Scholarship Exam. appear in these pages.**

# NEW COMPOSITION STORIES.—STANDARD V.

**Suitable for 'Unseen Tests' in Reading also.**

242.

THE DUTCHMAN'S RUSE.—A Dutchman, at a certain fair in Holland, proclaimed that in his booth was a donkey whose tail was where his head ought to be. Each visitor, on payment of his entrance money, was pledged to secrecy as to what he was going to be shown, full permission being given to say if the claim was true. What the visitors did see on entrance was a donkey with his tail tied to the manger.

243.

DECLINED.—One Sunday, when the congregation happened to be unexpectedly large, the rector, seeing that there was only one alms-dish, beckoned to a rustic and bade him go through the garden into the rectory dining-room and bring a dish from the table. 'Take it down one side of the north aisle and up the other,' he said, 'and then bring it to me.' The rustic disappeared, came back with the dish, took it as he was ordered and presented it to the people on either side of the aisle, and then, approaching the rector, whispered in his ear:—'I've done as yer told me, sir. I've taken it down yon side the aisle and up t'other—they'll none on 'em 'ave any.' The dish was full of biscuits!

244.

A CLEVER TRICK.—A gentleman, travelling in Russia, saw a Cossack leading a very lame horse, upon which, between his sobs of grief, he bestowed every possible encouragement to urge it onward. The poor beast, however, fell nearly in front of the inn, and to all appearances died. At this the Cossack's grief knew no bounds; he fell upon the horse's neck, covered it with kisses, and seemed quite heart-broken. The scene touched the hearts of all who had gathered round, and a handsome collection was soon made to compensate the poor man for his loss. His thanks were profuse, and, removing the saddle from the horse he swung it on his back and left. Having reached a safe distance, he stopped and gave a peculiar shrill whistle, upon hearing which the horse which he had left for dead galloped to him. It did not take the man long to swing himself on his steed, and a few moments after he disappeared at a turning in the road. It afterwards transpired that the man was well-known, and had performed this trick on several occasions.

245.

ABSENCE OF MIND.—An instance of absence of mind is recorded of Sir Walter Scott. Entering a room, one day, he found a friend reading a volume of poetry aloud to some ladies. He sat down and listened for some moments. At last a tear was seen stealing down his cheek, and, rising from his chair, he crossed the room, and looked over the reader's shoulder to see the author's name. Imagine his surprise at discovering the poem to be his own!

246.

TO SAVE THEM.—After a recent fire in which a farm was almost completely destroyed, the owner, walking over the ruins, came upon an old black hen. He wondered that she did not move her head to look at him as he came near her, but he thought she must be asleep. He poked her with his cane, and, to his surprise, the wing which he touched fell into ashes. Then he knew that she had been burned to death. But out from under her came a faint little peep, and, pushing her aside with his cane, the man found ten live yellow chickens. The hen had sacrificed her own life to save them.

247.

IT DIDN'T ANSWER.—A man went into the country one Sunday for a walk. He carried his overcoat on his arm, but, finding it burdensome, hung it on a fence. Taking a card from his pocket, he wrote:—'Do not touch this coat—infected with smallpox.' He came back about two hours later and found the card, upon which was written underneath his warning:—'Thanks for the coat; I've had the smallpox.'

248.

SNUFFED HIM OUT.—In a crowded street an ill-natured mastiff seized a little dog by the throat and began viciously shaking him. A crowd soon gathered. Words, blows and kicks failed to make the mastiff let go his hold. The little dog was howling piteously. At this juncture, when the lookers-on were wondering what to do, a young man, exquisitely dressed, came along. He at once comprehended the situation. 'Leave him to me,' he said; 'I can manage him.' At this there was an incredulous laugh from the crowd. The young man drew from his pocket a silver snuff box, and held a pinch of snuff under the mastiff's nose. The powder soon did its work. The big dog began sneezing vigorously, and of course had to open his mouth. He dropped the little dog and took to his heels, frightened and ashamed, his tail drooping like a whipped cur's. The crowd broke into a round of applause; the young man smiled and went on his way.

249.

A LAST RESOURCE.—The captain of an East Indiaman once used a pig to compel the crew to do their duty. The ship was largely manned by Hindoo sailors, who, as long as the vessel was in the warm latitudes, cheerfully did their work. When, however, the higher latitudes were reached, the men suffered from the cold and began to shirk their duty. At last they refused to come on deck, and in spite of threats and even blows, remained below in the forecastle. A happy thought struck the captain; he ordered a rope to be tied to the leg of the ship's pig, and had the animal lowered into the striker's quarters. Immediately every Hindoo, fearing his caste might be broken, rushed on deck to avoid contact with the contaminating beast.

250.

PAINTING A CAMEL.—An elephant once played an amusing trick upon a camel which was its neighbour in a menagerie. One of the workmen had been engaged in painting a portion of the house, touching off the ornamental projections with red paint. The young elephant watched him with great interest, apparently amused at the bright bits of colour. The painter was absorbed in his work when the dinner-bell rang. He put his pot and brush down, and went off to his meal. The elephant waited till he was out of sight, then carefully felt for the brush with his trunk. Next to the young elephant stood a sleepy camel, dreamily eating hay. The elephant took up the brush and streaked the camel's side. The keeper happened to come along just then, and watched events. The elephant appeared highly pleased when it saw the red line of paint on the camel's grey flanks. When the painter returned, the brush was back in its place, the elephant was gazing earnestly into space, and the camel was emblazoned all over with red stripes, like a crimson zebra!

251.

AN INGENIOUS OFFER.—An ingenious tramp called at a house and offered to kill all the rats in the house for a good meal. This was served him, and he ate to his heart's content; then, rolling up his sleeves and sitting on the floor, he asked for a block of wood and an axe. The housewife provided these; and 'Now,' said the tramp, 'bring in the rats!'

252.

'GO ABOUT YOUR BUSINESS.'—Upon the old Temple clock there is a singular inscription, the origin of which is said to have been a lucky accident. About two hundred years ago, a master workman was employed to repair and put a new face upon the clock. When his work was nearly done he asked the Benchers for an appropriate motto to carve upon the base. They promised to think of one. Week after week he came for their decision, but was put off. One day he found them at dinner in commons. 'What motto shall I put on the clock, your lordship?' he asked of a learned judge. 'Oh, go about your business!' his honour cried angrily. 'And very suitable for a lazy, dawdling gang!' the clock-maker is said to have muttered as he retreated. It is certain that he carved 'Go about your business' on the base. The lawyers laughed and decided that no better warning could be given to them at any hour of the day, and there the inscription still remains.

253.

THE MISSING ONE.—A ship-load of fine horses was once consigned from Calcutta to Bombay. While they were being landed at the slip, they managed to break away from the men in charge and ran like wild animals through the city. The foreman caught one of them, and mounting him, gave chase. After several hours of exciting work, with the help of his men he had captured all but one of the horses, as he counted them. Finally he made his reluctant way to the superintendent's office to give an account of the matter. The superintendent came to the door and listened to his story. 'And you say there were one hundred and twenty-four horses in all, and you have eighty of them in the company's stables, and forty-three back in the steamer temporarily?' 'Yes, sir, all safe but one, and we cannot find him anywhere.' 'What is that horse you are riding, have you counted him?' asked the superintendent. 'Well, I am an ass! Of course this is one of 'em!' And the foreman rode off in disgust, while the superintendent roared with laughter.

254.

THEY FLED IN DISMAY.—A white man who was taken prisoner by an inland tribe had a cork leg. Noticing that his captors were building an oven he became nervous, and to conceal his fear called for something to eat. Food being given him, he used a large jack-knife to cut it up. Between every mouthful he stuck the jack-knife into his leg with such force that it stood erect. The natives looked on in great astonishment and evident alarm. After the meal was over he began to unscrew his leg. That was too much for the poor savages. They hadn't the slightest curiosity to see what he would do next, but opened a passage for him and let him walk away unmolested. When he reached his horse the natives began to gather around, but after mounting he made a motion as if to unscrew his head, and the spectators fled in dismay.

255.

THE DOCTOR'S PRESCRIPTION.—A celebrated physician was out one day walking when he met an old gentleman who was very rich, but who was at the same time noted for his extreme meanness. The old man imagined he could get some medical advice without paying for it; so he stopped the doctor, and said: 'Doctor, I am feeling very poorly.' 'Where do you suffer most?' asked the medical man. 'In my chest, doctor.' 'Ah! that's bad. Please shut your eyes. That's right. Now put out your tongue, so that I can examine it closely.' The invalid did as he was told. After he had waited patiently for about ten minutes, he opened his eyes, and found himself surrounded by a crowd, who supposed he was crazy. The doctor, in the meantime, had disappeared.

256.

HE WISHED HE HADN'T SPOKEN.—On their arrival at New Zealand a party of tourists drank the health of the vessel which had brought them safely to their destination. One of the gentlemen who was asked to join in the ceremony replied: 'No, I am a tectotaler; but I'll willingly drink success to the ship in the liquor she floats in.' A friend disappeared, and returned with a glass of water. After a complimentary reference to the ship the recipient tossed it off at once, but immediately spluttered: 'Ugh—what's this?—I'm poisoned—ah—ugh!' 'That's a glass of the liquor the ship floats in!' replied the other.

257.

THE WILL ON THE HEARTHSTONE.—A solicitor in a country district was called from his bed about one o'clock on a cold winter's night to prepare the last testament of an old farmer who resided some three miles away, and who was rapidly dying. The messenger had brought a cart to convey the lawyer to the farm, and after a miserable journey he duly arrived at his destination. When he entered the house he was ushered into the sick man's room without delay, and he then requested to be furnished with pen, ink, and paper. But to the lawyer's astonishment there were none in the house. He had never thought of bringing any himself, so what could he do? 'Have you any lead pencil?' he inquired. 'No,' was the answer; 'we have none.' The farmer was sinking fast, though all the time quite conscious. At last the man of law saw written on the bedroom door column after column of figures in chalk. In this way the milk 'scores' or accounts, had been kept. He forthwith asked for a piece of chalk, and then kneeling on the floor, wrote out upon the hearthstone all the required details of the last will and testament of the dying man. The farmer soon passed away. The hearthstone will was forwarded to London, and was duly proved.

258.

HE GOT IT.—An Irishman on one occasion passed a grocer's shop, and, seeing a pile of cheeses on the counter, and noticing the shopman had left the shop, thought it a good opportunity to get a cheese for nothing. He therefore stepped lightly into the shop and, taking a couple of cheeses, placed one on each side of the scales. The shopman, hearing the noise, came from the back shop and asked Pat what he was about. 'Och,' said Pat, 'don't annoy yourself; I only wished to know if your cheese or mine is the heaviest.' 'Like your confounded impudence,' said the shopman, angrily; 'if you don't take your cheese out of this at once I'll set the police on you.' Pat lifted the cheese, and, smiling at the trick he had performed, bade the shopman a respectful 'good-day' and departed.

259.

MR. SKELETON MOVED HIM.—A physician in a small town had long been pestered by a little street arab, who came to sell wax-lights. At last, when patience had ceased to be a virtue, he told the boy to go into the next room, where there was a fellow who smoked. The young rascal went in, and his eyes fell on an all-grinning skeleton, swaying and nodding in the breeze. The boy's hair stood on end, he dropped his stock-in-trade instantly, and scampered off as fast as his legs would carry him. The physician, a kind-hearted man withal, and very tall and lank by the way, fearing that he had carried the joke too far, picked up the wax-lights and ran to the pavement, crying out, 'Come back, boy, there's nothing here to hurt you.' 'Oh, no,' said the boy, 'you don't come that over me; I know ye if you *have* got your clothes on.'

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## COMPOSITION TESTS.—STANDARDS VI. AND VII.

For Composition write at least 25 lines on *one* of the following:—

7. Say what you can about athletic sports, and show the advantages of drill and physical exercises to boys and girls;

8. Write what you can about the consideration and respect you should show to old age, referring especially to your parents, etc.

9. Describe the difference between sunrise and sunset.

10. Say what you can about the out and indoor amusements of boys and girls.

11. Say what you can about honour in word and act, especially referring to your own conduct in this matter when under examination;

12. Contrast the pleasures of winter with those of summer.

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## NEW READING TESTS.—STANDARD III.

**Suitable for 'Unseen Tests' in Dictation also.**

197.—One day you will be pleased with a friend and the next day disappointed in him. It will be so to the end, and you must make your mind up to it and not quarrel, unless for very grave causes. Your friend, you have found out, in not perfect. Nor are you, and you cannot expect to get much more than you give. You must look for weakness, foolishness, and vanity in human nature.

198.—'Well, Tom,' said a blacksmith to his apprentice, 'you have been with me now three months, and have seen all the different points in our trade; I wish to give you a choice for awhile.' 'Thank you sir.' 'Well, now, what part of the business do you like best?' 'Shutting up shop and going to supper, sir.'

199.—Some of the great deserts can only be crossed on the backs of the patient camels. The women and merchandise are carried this way, and the men follow on foot, singing a low song to encourage the poor brutes. When this 'ship of the desert' is tired or overladen it utters cries of distress, and if no notice is taken of it, it will suddenly kneel down, groaning, creaking, and grumbling.

200.—'Look here, waiter,' said a gentleman the other day. 'Is there any difference in your roast lamb and roast mutton? I don't detect any.' 'Oh yes,' said the waiter; 'you will notice that yesterday, when you had roast lamb, I charged you eighteenpence. To-day, when you had roast mutton, I only charged a shilling! There's the difference!'

201.—Pigeons like a quiet place, and their home should be sheltered from too much rain and from high winds. Cleanliness is most essential to their well-being; so is a good supply of pure water: if near a stream, they may be left to procure

this for themselves. They will probably manage to forage for themselves during the day, but should always be fed well before roosting time.

202.—The following took place at a railway station in a remote part of Devonshire. Just as the signal had dropped for the express to run through, an excited rustic ran up to the station-master, and said: 'Please, sir, I don't know if it makes any harm, but that ere board has just fallen down!'

203.—The harpy eagle of South America is the biggest and fiercest of all birds. Its claws and toes are longer and more robust than a strong man's fingers. The Indians hold this bird in great respect, and adorn themselves with its feathers on all state occasions. They live in dense forests, and feed on fawns, sloths, and especially monkeys, which they devour with great relish.

204.—Two young London ladies in the country were standing by the side of a wide ditch, which they did not know how to cross. They appealed for help to a boy who was coming along the road, whereupon he pointed behind them with a startled air, and yelled: 'Snakes!' The young ladies each crossed the ditch at a single bound.

205.—Monkeys attach themselves warmly to those who show them kindness, and when brought away in ships from their native land, they often grow very fond of the sailors on board. I heard of one who had signs for the cabin-boys whenever he wanted anything, and if they failed to attend to him, he instantly flew into a violent rage, and would seize them and hold them down.

206.—The school treat at Arundel Park was a truly grand one. It was a day of brilliant sunshine and sweet fresh air, and the poor London children rejoiced greatly. There was a nice dinner and tea provided in a large tent, and games of all sorts; cricket, racing, running for prizes, and swings.—(H.M.I.'s Test.)

207. There is beauty all around,
When there's love at home;
There is joy in every sound,
When there's love at home.
Peace and plenty here abide,
Smiling sweet on every side,
Time doth softly, sweetly glide,
When there's love at home.

## NEW DICTATION TESTS.—STANDARD IV.

**Suitable for 'Unseen Tests' in Reading also.**

No. 142.

Some soldiers once fell upon a watchman in a small town, in a lonely street, and took away his money and coat. He immediately repaired to the captain of the regiment to complain of his misfortune. The captain asked him whether he had on the waistcoat he then wore when he was robbed by the soldiers. Yes, sir, replied the poor fellow. Then, my friend, rejoined the captain, I can assure you they do not belong to my company; otherwise they would have left you neither waistcoat nor coat.

No. 143.

There is a great society at Holland for watching and controlling the water which would engulf the country were it not for the dykes. Everybody in the land is obliged to obey the commands of this institution. If any one sees the water threatening to pour in he must at once give the alarm, and all the people of the district, and of the districts round about, must be summoned by the ringing of the alarm bells and by the booming of cannon, and then old and young, rich and poor, soldiers and public servants, must all set to work together and fight the common foe.

No. 144.

Fish-hatching in China is sometimes conducted with the aid of a hen. The spawn is collected from the water's edge, and placed in an empty egg-shell. The egg is then sealed with wax and placed under a sitting hen. After some days the egg is carefully broken, and the swarm emptied into water well warmed by the sun. There the little fish are nursed until they are strong enough to be turned into a lake or stream.

No. 145.

The Minister of Public Instruction in Germany has issued an order forbidding school-girls to carry more than a certain weight of books in their passage to and from school every day. The German maiden generally carries her school-books in a kind of knapsack strapped across the shoulders, and the police are now empowered, whenever they see the children overloaded, to summon the fathers, who are subjected to a heavy fine.

No. 146.

Every steamer that plies along the Atlantic coast is a refuge for birds that are blown out to sea, mostly small and not strong of wing. When disturbed or frightened by people on the deck they fly into the air and fall behind the ship, and after several such disturbances they become so tired that they can no longer catch up. After hopelessly chasing the vessel for several miles they flutter into the sea and are drowned.

No. 147.

Life has glimpses which we would do well to cherish and make the most of. Never do we see or know, much less do we feel or experience, the whole of everything. Only by receiving little by little as it comes to us, eagerly yet patiently, and putting together what we receive as skilfully as we may, do we attain any degree of clear or true conception. He who insists on more than this will forfeit all.

No. 148.

While a diver was engaged off the coast near Gibraltar in the search for the whereabouts of a recent wreck, he discovered at the bottom, from eighty to one hundred large guns, mostly 24 and 32-pounders, and two big anchors. As no appliance for raising them was at hand, they were not brought up, and their nationality has not been ascertained. It is supposed that they belonged to a line-of-battle ship which sank in the Peninsular war, possibly after the battle of Trafalgar.

No. 149.

If you should go into a garden ignorant of botany you would see many plants seemingly of no value, and only an expense, but which yet turn out precious herbs or produce rare flowers, whose beauty is their own excuse for being, and excuse enough beside. So in the garden of mankind, which God only understands, there are various employments which seem at first to be of no value, but which turn out to be of the greatest importance.

No. 150.

Canals appear to have taken out a new lease of life. In England there are many signs of a desire to return to this good old-fashioned means of transit. Our railways have been having things too much their own way. They have more work almost than they can do, and they charge more than they ought for doing it. The much-despised old water-ways between the great commercial centres of England are to be overhauled, and set going once more for the conveyance of goods.

No. 151.

In former times live oak was largely used in naval construction, and warships had their frames and planking made principally of this wood, so that a web of historical sentiment and romance has been woven about the tree. The wood is still used to a considerable extent in building ships, but its value has increased largely on account of the diminished quantity now available.

No. 152.

We hear a great deal in these days about national honour. I feel for it as strongly as anyone, and I only wish we were more sensitive on that point. Pauperism is to my mind national dishonour; so is drunkenness; so is the misery in which our poorest classes in the large towns live, even when they escape the workhouse. These are the most real and formidable enemies we have to contend with; and depend upon it, if we attacked them seriously we should have fighting enough at home to last our time.—(H.M.I.'s Test.)

No. 153.

When is the time for prayer?
In every hour, while life is spared to thee—
In crowds or solitude—in joy or care—
Thy thoughts should heavenward flee.
At home—at morn and eve—with loved ones there,
Bend thou the knee in prayer!

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STANDARDS V.—VII., AND 1ST AND 2ND YEAR P.T's.

No. 130.

THE old Teutonic and Saxon term, 'God's Acre,' as applied to the last resting place of the human body, Longfellow made the theme of one of his most touching and beautiful poems; it is an eminently suggestive term. The acre or field of God contains the seed hidden in the ground for a while, to ripen into a glorious harvest; and, just as we write the labels in the spring time for seed we put in the ground, that we may remember what beautiful flower is to spring from the little gray atom, so we put a stone at the head of the grave of our dead. The name 'cemetery' also signifies merely the place where one may lie, slumbering for awhile, till the dawn shall come and the trumpet sound.

No. 131.

RICE is, no doubt, the most extensively used article of food the world over. Hundreds of millions of people chiefly subsist on it, and its consumption is constantly increasing. It is the principal diet of at least one-third of the human race, forming the chief food of the native populations of almost all Eastern nations. The Eastern nations also chiefly obtain their beverages from rice, which is the principal grain distilled. Saki, or rice beer, is produced in Japan to the extent of 150,000,000 gallons annually. Although rice is such a universal article of food, it is not so nourishing as wheat or some other grains. More than nine-tenths of its substance consists of starch and water; consequently it forms more fat than muscle.

No. 132.

THE Bank of England strong room is one of the largest in the world. The foundation, which is sixty-six feet below the street level, is a bed of concrete twenty feet thick, to prevent anyone from digging his way into the chamber. Above this concrete is a lake seven feet deep, and above are thick plates of iron, specially manufactured to resist both skill and force. Anyone attempting an entrance from the ceiling would find a similar bed of concrete, a similar lake, and similar iron plating. The walls are equally impenetrable. The doors are a foot thick, and each one weighs four tons. They are made of a compound of flint and iron, and are absolutely undrillable.

No. 133.

THE most remarkable canal in the world is in the north of England. It is sixteen miles long and underground from end to end. In Lancashire the coal mines are very extensive, half the country being undermined, and many years ago the Duke of Bridgewater's managers thought they could save money by transporting the coal underground instead of on the surface. So the canal was constructed and the mines connected and drained at the same time. Ordinary canal boats are used, but the power is furnished by men. On the roof of the tunnel arch are cross pieces, and the men who do the work of propulsion lie on their backs on the coal and push with their feet against the cross bars on the roof.

No. 134.

THE Gothic nations of old were famous for the quantities of food and more particularly drink they could consume. In those days gluttony and drunkenness were so very common that they were not thought a disgraceful but rather a laudable vice. Under this persuasion, it was enacted in the law that judges should hear and determine causes fasting, and not after dinner. From this propensity of the older Britons to indulge excessively in eating and drinking has proceeded the restriction on jurymen to refrain from meat and drink, and to be even held in custody, until they have agreed upon their verdict.

No. 135.

CANARIES, linnets, and other songsters may be taught a variety of airs by hearing them played or whistled to them repeatedly, and thrushes have been known to reproduce a portion of an opera. They listen with attention and imitate the strains that take their fancy. If harmony or the concord of sweet sounds, as distinguished from melody or the simple succession of sweet sounds, does not enter into bird music, the same may be said of the music of primitive man and of all early nations. Savages, like feathered songsters, sing in unison, but not in accord.

No. 136.

GRANITE is the lower rock in the earth's crust. It is the bed rock of the world. It shows no evidence of animal or vegetable life. It is from two to ten times as thick as the united thicknesses of all the other rocks. It is the parent rock from which all the other rocks have been either directly or indirectly derived. It is true that it does not contain lime, while limestones do contain that substance, but it furnishes the foundation for vegetable growth. Vegetable growth furnishes the foundation for animal growth, and animal growth brings lime into existence. It is claimed by scientists that all the lime in the world has, at some time, been a portion of some animal. The same atom of lime has some time, no doubt, been a portion of many different animals, and possibly of human beings also.

No. 137.

HELIGOLAND has a small prison or lock-up, but they rarely lock anyone up, as they do not care to board the prisoner. There is also a small cottage hospital ready for use if necessary, but patients are few and far between. There is also a poorhouse. Here poor people live rent free. The plan adopted is for parents and children to go before the magistrate, when the former resign any little property they may possess to their children, who in turn promise to find them in food. When the husband dies the wife takes his property, and at her decease it is equally divided between the children.

No. 138.

ENGLISH farm servants habitually wear thick leather boots, which will not yield or allow the foot to bend. The natural result of this is that the muscles of the calf are hardly used at all, and in consequence they dwindle away into insignificance. That is why even Londoners, leading a sedentary life, have their legs better developed than their country cousins. For whenever they do walk they wear light and flexible boots, and raise the heel slightly before the boot is lifted from the ground. This, of course, brings into continual action all the muscles of the leg, and is indeed the only graceful way of walking.

No. 139.

ABOVE all things be on your guard against your temper. It is an enemy that will accompany you everywhere, to the last hour of your life. If you listen to it, it will frustrate all your designs. It will make you lose the most important opportunities, and will inspire you with inclinations and aversions to the prejudice of your greatest interests. Temper causes the greatest affairs to be decided by the most paltry reasons. It obscures every talent, paralyses every energy, and renders its victims unequal, weak, vile and insupportable. (H.M.I.'s Test.)

No. 140.

OF this fair volume, which we World do name,
If we the sheets and leaves could turn with care,
Of Him who it corrects, and did it frame,
We clear might read the art and wisdom rare:
Find out His power which wildest powers doth tame,
His providence extending everywhere,
His justice which proud rebels doth not spare,
In every page—no period of the same.
But silly we, like foolish children, rest
Well pleased with colour'd vellum, leaves of gold,
Fair dangling ribbons, leaving what is best,
On the great writer's sense ne'er taking hold;
Or if by chance we stay our minds on aught,
It is some picture on the margin wrought.

# OUR 1895 CERTIFICATE CLASS.

BY J. C. HOROBIN, M.A.,
*Principal Cavendish College, Cambridge.*

The Examination commences on June 24th at 2 p.m. The subjects, failure in which excludes from a certificate, are marked (*f*). Optional subjects are marked (*o*).

FIRST YEAR.

| Subjects. | Maximum Marks. | Men. | Women. | Notes. |
|---|---|---|---|---|
| Reading - - (*f*) | 50 | Same - - - | 'Merchant of Venice' - | It is advisable to get a good edition, such as the Clarendon Press or Temple 'Shakespeare,' and to read a little every day, paying special attention at first to the rhythm.<br>☞ FOR PUBLISHED PRICE OF BOOKS RECOMMENDED, SEE OUR ADVERTISEMENT COLUMNS. |
| Repetition - (*f*) | 50 | Same - - - | 200 lines - - - - - | As the set book for the English fulfils the requirements, students are advised to choose their lines from that work, keeping in mind in their selection of passages that they can materially help their English by choosing passages which will illustrate—<br>(*a*) The distinctive style of the author.<br>(*b*) Peculiar constructions or rhythm.<br>(*c*) Passages renowned for their descriptive or didactic beauty.<br>The selections are published by Macmillan. |
| Penmanship - (*f*) | 75 | Copy setting, text and small. General character of writing - | Same - - - - - | Hughes' 'Certificate Copy Book.' Students should endeavour to make their ordinary hand of the same style as they adopt in copy setting. |
| Spelling - - (*f*) | 100 | Dictation - - | Same - - - - - | There are two difficulties in this exercise—<br>(*a*) Verbal.<br>(*b*) Phrasing.<br>The first is best prepared for by (1) reading every day a few lines from an author like Gibbon or Macaulay, noting every word as a collection of letters, and (2) in writing from dictation short lists of words which the student has found difficult.<br>The second is much more difficult to do well, as it requires—<br>*(1) A good knowledge of part of the grammar.<br>(2) A well-trained ear. |
| School Management. (*f*) | 100 | Same - - - | (1) General principles.<br>(2) Methods of teaching—<br>(*a*) Elementary subjects.<br>(*b*) Class subjects.<br>(*c*) Drawing.<br>(3) Methods and principles of—<br>(*a*) Infant teaching.<br>(*b*) Infant discipline.<br>(*c*) Cultivating the intelligence.<br>†(4) Notes of lessons. | It is not easy to find a book giving the sort of aid that is required for the first section. Cowham's 'Oral Training' is good, but general principles are best studied incidentally in such books as Quick's 'Educational Reformers,' Spencer's 'Education,' and in Articles such as those by Mr. Cartwright in the PRACTICAL TEACHER of last year.<br>For (*a*) and (*b*) of the second section see Flux's 'School Management.'<br>For (*c*) the special Articles in the PRACTICAL TEACHER by Mr. Buffery Ridge give good hints.<br>Sec. (3) is dealt with in Flux up to the standard of scholarship, but useful additional matter may be obtained from Gladman's 'School Work,' and every infant teacher should take the *Infants' Mistress* and study carefully the Articles therein referring to their particular work, especially to courses illustrating (*c*). |
| Music - - (*o*) | 40 | Same - - - | Musical terms are omitted. There is no other change. | Every student ought to attempt this paper. Dunstan's 'Manual' or Curwen's 'Standard Course' give all and more than is required. |
| Composition - (*f*) | 30 | Same - - - | Plain prose on a given subject. | A separate paper is now set in this subject, lasting one hour. Practice is the only way to obtain facility, and general reading provides the material. An exercise should be done at least every week. In selecting a |

* For (1) see Dr. Beach's 'English,' pages 124–129 and 161, 162. For (2) the best preparation is to get a good reader to read several of the passages that have been set before, or if this be not possible, the student should read the passages aloud, noticing carefully the effect on reading them as marked or differently.

† There is no part of the S.M. paper in which the practical teacher ought to score more than in Notes of Lessons, because no part lends itself more easily to originality. But the student should carefully note that the Examiner has to assess the *teacher* not the *student*, and, therefore, METHOD or HOW is more important than *matter* or *what*. The most common errors are—
(*a*) To give more matter than can be dealt with in the time allowed for the lesson.
(*b*) To give matter unsuitable to the average calibre of the chosen class.
(*c*) To be irrelevant and out of proportion in the introductory matter.
(*d*) To give the matter and method *per saltum* and not by process of continuous development.
(*e*) To ignore or forget the principles which the candidate has probably enunciated in another part of the paper.
Sections 2 and 3 presuppose a knowledge of the requirements of the Education Code. The N.U.T. edition is the most suitable for the student's purposes.

| Subjects. | Maximum Marks. | Men. | Women. | Notes. |
|---|---|---|---|---|
| | | | | subject take such an one the matter of which is well grasped. Arrange the order of treatment before beginning to write. Be sparing of quotations, and let the diction be as simple as possible. Make the paragraphs distinctive and self-contained. The golden rule, so far as the Examination is concerned, seems to be, Let the exercise be a good model for the upper standard of a school.<br>Useful hints and exercises will be found in Dawson's 'Essay Writing and Paraphrasing.' |
| English (*f*) | 100 | Same | (1) Parsing.<br>(2) Analysis.<br>(3) Principles of Grammar.<br>Selections from Tennyson, Parts I. and II. | The first three sections are well dealt with in Beach's 'English' and Dickinson's 'Difficulties of Grammar.' The selections are by Rowe (Macmillan & Co.)<br>The paper distinctly and definitely follows the syllabus, and it is as necessary to be well acquainted with the literature of the set book as to be able to analyse and parse.<br>Speaking generally, if the exercises for parsing are taken from the piece to analyse, it is better to do the analysis first. The parsing then gives a check on the analysis and should agree with it. If the words for parsing are given in detached passages, the student will find it prevent many mistakes if the passage is analysed roughly on the scrap.<br>The student who can give the time will find Stopford Brook's 'Tennyson' very interesting and helpful. |
| Geography | 75 | Same | (1) (*a*) Shape, size, and motions of the earth.<br>(*b*) Atmosphere, rain clouds, and vapour.<br>(*c*) Winds, currents, and tides.<br>(*d*) Cause which affects climate.<br>(2) Europe. Map of any part of England. | Gregory's 'Physical and Astronomical Geography' and 'The Planet Earth,' with Brook's 'Descriptive Geography,' will quite cover the ground.<br>The motions of the earth, vapour, currents and tides require the most careful attention.<br>The historical, ethnographical, and commercial parts of geography are receiving more and more attention by the Examiners. |
| History | 75 | Same | 1760 to 1820 | Boyd Carpenter and Green's 'Outlines'; Green's 'Main Facts.' Davies' 'Historical Manual' for the period.<br>It is important to notice that the questions will be confined to the special period. |
| Arithmetic (*f*) | 100 | (1) Arithmetic generally.<br>(2) Explain and prove the rules. | (1) First four rules.<br>(2) Practice and Bills.<br>(3) Vulgar and Decimal Fractions.<br>(4) Interest.<br>(5) Simple and Compound Proportion.<br>(6) Explanation of the best methods of solving sums mentally. | Dixon and Beach's 'Girls' Arithmetic'; Wollman's 'Arithmetic'; Pendlebury, an excellent collection of difficult problems; Piper's 'Mental Arithmetic.'<br>Section (6) is new, and is put in the place of the old exercise. Students may expect questions which will test their powers of introducing new rules to a class by 'preparatory oral exercises.'<br>In the men's syllabus, section (2) is very important. Since algebraic symbols are allowed, the algebraic proofs of the rules are the best to give.<br>The *explanations* of rules should follow the standard text books, such as Dixon or Pendlebury. |

WOMEN ONLY.

| Subjects. | Maximum Marks. | Syllabus. | Notes. |
|---|---|---|---|
| Domestic Economy | 75 | (1) Food.<br>(2) Clothing.<br>(3) Fresh Air. | Hughes' Domestic Economy—pages 85–99, 100–124, 135–146, 149–162, 213–245, 377–409. |
| Needlework (*f*) | 100 | (1) Repairing any plain article of underclothing.<br>(2) Diagrams—<br>(*a*) Woman's chemise.<br>(*b*) Infant's shirt.<br>(3) Cutting out and making one of the above.<br>(4) Questions on Needlework. | Useful hints will be found in Miss Warren's book for section (4), and Miss Rosevear's Manual covers the full course. Perhaps the most frequent failure at the Examination is neglect of proper proportions in the parts of the garments set for different ages. This is entirely due to neglect in observing that some parts of the body alter materially in size in, say, two years, whilst others practically remain stationary. For example, a child of four will require a neck almost as wide as a child of six on the average, but the body length will be quite different as a rule. |

## MEN ONLY.

| Subjects. | Maximum Marks. | Syllabus. | Notes. |
|---|---|---|---|
| Algebra and Mensuration. | 100 | Four simple rules.<br>Involution and Evolution.<br>Common Measures and Multiples.<br>Fractions.<br>Surds.<br>Ratios.<br>Proportions.<br>Simple Equation.<br>Easy Quadratics.<br>Mensuration of plane rectilinear figures and circle. | C. Smith's 'Elementary Algebra'; Henchie's 'Mensuration'; Horobin's 'Certificate Tests in Algebra and Mensuration.' (This contains the last ten years' questions arranged under the different rules, and full solutions are obtainable.)<br>The Examiners expect the book work to be thoroughly known, and it is important to notice that, though algebra may be used in an arithmetic paper, arithmetic illustrations in an algebra paper are worthless. |
| Euclid - - | 100 | First two books. | Deighton's is one of the best of the modern Euclids.<br>Euclid's *order of propositions must be maintained*, but the proofs may be Euclid's or otherwise. |

### LANGUAGES.

A candidate may not take up more than—

Two Languages OR two Sciences.
One Language *and* one Science.

Choice may be made from Latin, French, German, Welsh, Hebrew. Each has for a maximum 100.

Each paper will contain :—

(*a*) An easy unseen passage for translation into English from a prose writer.

(*b*) Grammatical questions.

(*c*) Passages for translation from and into English.

The set books are :—

Cæsar, 'Gallic War,' first half of Book VII.
Coppée, 'Le Tresor.'
Schiller, 'Der Neffe als Onkel.'
'Cymni Fu,' first 63 pages.
Book of Genesis, cc. 27–50.

### DRAWING.

Candidates may obtain marks for certificates in the following subjects or their equivalents (see p. 64 of 'Science and Art Directory') :—

| | |
|---|---|
| Freehand - - - - - - - | 40 |
| Model Drawing - - - - - - | 40 |
| Shading from Casts - - - - - | 40 |
| Elementary stage, Sc. Subject I. - - | 60 |
| Model Drawing with chalk upon the blackboard - - - - - - - | 20 |

### SCIENCE.

Marks (Advanced or Honours, 100; Elementary, 75) may be obtained for success by acting teachers at EITHER or BOTH of the May Examinations, 1894 and 1895, open to them. No candidate can obtain marks for more than two subjects except in substitution for Geography or History, or both, from which exemption has been obtained by passing with exceptional credit in either or both of these subjects at the Scholarship Examination.

The subjects from which choice may be made are :—Mathematics, Mechanics (Theoretical and Applied), Sound, Light, and Heat, Magnetism and Electricity, Inorganic Chemistry (Theoretical and Practical), Human Physiology, Botany, Physiography, Agriculture, Hygiene. Alternative Physics may be taken as an alternative for Sound, Light, and Heat, or Electricity.

## SECOND YEAR.

| Subjects. | Maximum Marks. | Men. | Women. | Notes. |
|---|---|---|---|---|
| Reading - - (*f*) | 50 | Lyall's 'Warren Hastings.'<br>As women. | Set book—<br>(*a*) As in First Year.<br>(*b*) Unseen.<br>To show improvement—<br>(*a*) Expression.<br>(*b*) Modulation.<br>(*c*) Correct delivery of long or involved sentences. | All H.M. Inspectors are paying more attention to reading, and the student will not find it easy to get full marks. Continuous practice in reading aloud with someone who is a good elocutionist is the best preparation. Some useful hints will be found in Hawkins' 'Reading and Reciting.' |
| Repetition - (*f*) | 50 | Same - - - | 200 lines from a play of Shakespeare. | Generally as in First Year.<br>The Clarendon Press edition of 'King Lear' is the best, as the notes are suitable for the English paper, and the text is good. |
| Penmanship - (*f*) | 75 | Same - - - | As in First Year. | |
| Spelling - - (*f*) | 100 | Same - - - | As in First Year. | |
| School Management. (*f*) | 100 | Same - - - | (1) Teach a Class.<br>(2) Organization.<br>(3) Registers and Returns.<br>(4) Processes of reasoning and the formation of habits and character. | Students will find the National Society's 'Complete Register' a great help in getting facility.<br>The N.U.T. edition of the Code gives specimens of all the forms that have to be filled up.<br>Section (4) is well dealt with in Cartwright's 'Mental Science and Logic.' |

| Subjects. | Maximum Marks. | Men. | Women. | Notes. |
|---|---|---|---|---|
| | | | (5) Laws of health—<br>(*a*) Premises.<br>(*b*) Scholars.<br>(*c*) Teachers.<br>(6) Notes of Lessons. | On Section (6) see First Year.<br>On Section (5) the student ought to read carefully the Instructions to Inspectors, and the Circulars of the Department respecting schools, playgrounds, etc.<br>Sections (2) and (5) are dealt with fully in one of Cowham's 'Manuals,' or Gladman. |
| Music—<br>(*e*)<br>Theoretical<br>Practical | <br><br>30<br>50 | Same | Transcription from one time to another and voice-training omitted. | Students should notice that the larger proportion of marks are given for the practical work, and that the theory paper cannot be taken unless a certificate for practical skill be obtained from some competent person. |
| Composition (*f*) | 30 | — | — | See First Year. |
| English (*f*) | 100 | Same | (1) (*a*) Grammar.<br>(*b*) Analysis.<br>(*c*) Paraphrase.<br>(2) Language, style, and subject matter of 'King Lear,' and Bacon's Essays, 1, 2, 4, 5, 9, 11, 14–19. | See First Year.<br>The Clarendon Press edition, for 'King Lear,' and Selby's 'Bacon,' are advised. |
| Geography (*e*) | 75 | Same | As in First Year. | |
| History (*e*) | 75 | Same | As in First Year. | |
| Arithmetic | — | — | Application of—<br>(1) Former rules.<br>Discount.<br>Stocks.<br>Insurance.<br>Square root.<br>(2) Explanation of the arithmetical processes employed.<br>(3) Alternative Algebra.<br>Four simple rules.<br>Involution.<br>Algebraic Fractions.<br>Simple Equations, one unknown. | A candidate who passed with credit in Arithmetic in the First Year may take:—<br>(*a*) Euclid I.<br>(*b*) Algebra to Simple Equations, inclusive, instead of Arithmetic. |
| Language | — | Same | More difficult questions, both in translation from and into English prose, with questions upon constructions.<br>(1) 'Gallic War,' Book VII.<br>(2) Malot, 'Capi et sa troupe,' Episode, 'Sans famille.'<br>(3) Goethe, 'Hermann and Dorothea.'<br>(4) Orian Thoyr (first 62 pages).<br>(5) Genesis (cc.), 27–50. | Same general conditions as in First Year.<br>Greek is omitted for men. |

MEN ONLY.

The subjects are grouped as follows :—

(*a*) English.
(*b*) Geography and History.
(*c*) Algebra, Mensuration, and Geometry.
(*d*) Two subjects of Science.
(*e*) Two Languages.
(*f*) Two of the following :—
  (1) One Language.
  (2) One Science.
  (3) Economy.

All candidates *must* take GROUP (A) and TWO other Groups, but no more. Group (*f*) may not be taken with (*d*) or (*e*).

A candidate who fails to pass with credit in Mathematics in the First Year papers must take that Group as *one* of the Groups; but he has the option of—

(*a*) Repeating the First Year course, with a maximum 25 per cent. less than for the Second Year course.
(*b*) The Second Year course.

Algebra and Mensuration—
(*a*) First Year's course.
Permutations and Combinations.
Binomial (positive integral indices only).
More difficult equations.
(*b*) First Year's course.
Cylinders, spheres, cones.

Geometry—
Euclid I.–IV., inclusive.
Simple deductions.

Drawing and Science as in First Year both for Men and Women.

WOMEN ONLY.

| Subjects. | Maximum Marks. | Syllabus. | Notes. |
|---|---|---|---|
| Domestic Economy. | 75 | (1) Choice, preparation, and due economy of articles of food in common use.<br>(2) Preparation of food for the sick.<br>(3) Household Management. | Hughes's 'Domestic Economy,' pages 213-245, 246-279, 413-417. |
| Needlework (*f*) | 125 | Higher branches, including—<br>(1) (*a*) Tucking.<br>(*b*) Whipping.<br>(*c*) Feather-stitching.<br>(*d*) Repairing linen and print.<br>(*e*) Darning in stocking-web stitch.<br>(2) Diagrams—<br>(*a*) Boy's shirt.<br>(*b*) Child's muslin pinafore.<br>(3) Cutting out and making one of the above, and cutting out and tacking together of the other. | As in First Year. |

### General Remarks on Routine.

Each student should make out a Time-table for himself or herself, having regard to—

(*a*) The time that can be spent each day, excluding Sunday and Saturday.

(*b*) The character of the subjects in which the student is strong or weak.

The greater proportion of time should be given to—

(*a*) Weak subjects.

(*b*) Those to which the student has a personal dislike.

(*c*) To the failing subjects.

It should be remembered that the division in which the successful candidate is placed depends on the aggregate marks, and therefore all subjects should be brought up to a good average.

Saturday is a day on which, generally speaking, longer time continuously can be given, and at least *two hours* should be allotted to attempting written answers to questions, and *two* to *revision* of the work of the previous five days.

Revise and write out is the surest road to success.

The Syllabus has come to hand too late to enable a complete routine for the month to be made out.

Students are advised—

### First Year.

(*a*) To read right through the selections from Tennyson purely for the literature and to get a general notion of the style. Mark the passages which interest most, and, having regard to the notes already given, if not already said, get up the repetition.

(*b*) In School Management to look up the requirements of the Code so as to be able to apply to a specific part of the Code work the knowledge obtained from the study of the theory.

(*c*) To read right through in the 'History Text Book' the part dealing with the special period and learn these dates as landmarks, 1763 (Paris), 1773 (tea ships), 1783 (Versailles), 1793 (Execution of Louis XVI.), 1803 (Assaye), 1813 (Wellington entered France).

Learn the provisions of the Six Acts which followed the Peterloo Massacre.

(*d*) In Geography confine the work to the physical part. A syllabus is given below for nine weeks' work, which will allow for the whole to be revised thoroughly. The 'General Geography' can be begun in April :—

(1) Shape of the earth—Proofs of its rotundity—Exact shape—How ascertained. Size of the earth—How ascertained—Methods of measuring one degree of arc of meridian, and of finding the latitude of a place [Greg., Chap. II.].

(2) Motions of the earth—[1]—Rotation—The facts—Proofs—Results—Day and night—Solar and siderial day—Longitude and time [Chap. III.].

(3) Motions—[2]—Revolution—Time occupied—Shape of Orbit—Varying speed—Proofs of revolution—Effects—Seasons—Length of day and night in different latitudes [Chap. IV.].

(4) Motions—[3]—Through space with system—Speed—Direction—[4] Precession, sufficiently to explain solar year [Chap. IV. in part].

(5) The atmosphere—Its weight—Composition—Height—Twilight—The barometer. Water-vapour—Evaporation and condensation—Mist—Cloud—Dew—Rain—Rainfall, how measured—Regions of excessive and scanty rainfall, and the causes thereof [Chap. IX.].

(6) Movements of the atmosphere and their causes—Constant—Periodical and variable winds—Cyclones anti-cyclones [Chap. X.].

(7) Movements of the oceans—Currents and theories to account for them—The chief ocean currents—Their temperature—Direction effects [Chap. XV.].

(8) Tides, phenomena of—Theories concerning them—Why moon the chief agent—Periodical inequalities and their causes—Course of the tidal wave [Chap. VIII.].

(9) Climate, what it is—Circumstances which affect it—Examples of equable and extreme climates—Isothermal lines [Chap. XVI.].

(*e*) In Arithmetic get up carefully the theory and history of our notation and numeration, definitions of terms, and Chaps. I. and XXIII. (Dixon).

Work all the questions on the subject-matter of these chapters in Wollman.

*Men* add Chaps. XXXIX.—XLI. with corresponding questions.

(*f*) Algebra—

(1) Proof that simple equations have only one root.

(2) Work as many examples of simple equations, especially with fractional terms, as possible, including problems.

(3) H.C.F. Proof of rule, and examples on it.

(*g*) Euclid. Definitions and axioms of First Book, with Props. 1 to 8 inclusive, and riders that can be dealt with up to that point.

### Second Year.

(*a*) As First Year, reading 'King Lear' for Tennyson.

(*b*) Chaps. I., II., and VII. of Cartwright.

(*c*) As First Year.

(*d*) As First Year.

(*e*) As First Year, but add theory and practice of square root.

(*f*) As First Year, but add proof and examples of *n Pr.*

(*g*) As First Year, but add definitions of Book III. and Props. I. to VIII. inclusive, with riders thereon.

Next month we shall give some notes on the Tennyson, 'King Lear' and Bacon, with suggested questions for attempting in all subjects, and a fuller routine of work.

## NOTES AND NOTIONS.

BY RICHARD WADDINGTON.

THE election of Vice-President of the N.U.T. will be practically over ere these lines meet the reader's eye. There is not much doubt as to the result. The President for 1896 is likely to be a member of the London School Board. It almost seems a pity that there should be a contest this year. The voice of the Associations points unmistakably to Mr. Macnamara, and I am not sure that the Union will receive adequate return for the seventy or eighty pounds spent on the contest.

THE march of Unionism continues. 1894 adds another two thousand to the roll. At present the Teachers' Union is the strongest union in the country, judged by the proportion of its clients within the pale of membership. And its influence in the educational world is proportionately great. The Union will continue its victorious course, I feel sure. The coming race of teachers are strongly Unionist, and herein lies the future of the Union. It is just possible that the Union may finally close its doors to the non-unionists who persistently stand aloof. Said an Inspector to me the other day: 'Any teacher who remains outside the N.U.T. is a fool.' Strong, but nevertheless true, even to the last word, is the statement.

'"Tis true, my fading years decline.'

AND, as the decline becomes more apparent, the teachers look to Mr. Acland for that promised legislation which is to secure the teacher from want in old age. The report of the Departmental Committee on the superannuation of teachers is still a matter of anxiety. Are we to get a reasonable scheme this year? Everything seems favourable. The financial experts talk of a surplus that is to be counted by millions. Mr. Acland is willing, and only awaits the assent of the wily Chancellor of the Exchequer. Can nothing be done to move Sir William? The Union is doing all it possibly can through its executive. What are the Associations doing? There ought not to be a single Member of Parliament who is not made alert to the necessity for doing something at once. An opportunity like this may not come again. The House of Commons has assented to the claim. The Vice-President is enthusiastically in its favour. The Scheme has been prepared by a Departmental Committee. The teachers must see that the question is not shelved for another session. What can they do? Interview! interview!! interview!!! Whom? The local member, *and at once.*

THE fortress is nearly scaled. Are we to fail at the last effort? I trow not, if teachers will but awaken from their slumbers. If the Chancellor of the Exchequer had a couple of hundred members of the House pressing for superannuation there would be little doubt of our getting a share of his surplus. It must not be forgotten that, with the tenure problem in its present unsatisfactory state, the case of the older teachers grows more pressing day by day. The rapid changes in the educational barometer are fraught with grave forebodings to the teachers who are well advanced in years. Suitable occupations, excessive drawing requirements, and object lessons may be naught to the younger generation, but to many the task is impossible. 'Too old at forty' rankles in the mind of many hard-wrought teachers, and the decision of the Cabinet on the question of superannuation is awaited with anxiety.

THE report of the Archbishops' Committee on the question of voluntary schools gives little consolation to those who demand a share of the rates. The committee, as did the committee of the N.U.T. Executive, asks for increased Imperial aid. State-aid, and not Rate-aid, is the plaint of the leading Churchmen. Even a cursory inspection of the problem confirms the wisdom of this contention. Rate-aid means universal Board Schools. To this I have no particular objection. Many of my friends, formerly Church teachers, are thriving under the Board School system. I have myself been employed under two large provincial School Boards. I don't remember that my Churchmanship suffered in consequence. I know few Church teachers who would not readily accept service under a School Board provided the salary and conditions were equal to those at present pertaining. The case lies in a nutshell. Universal Board Schools are at present without the pale of practical politics. The dual system, as at present existing, too often means starvation for the teachers, and, therefore, for education. The sects will retain their schools at any price, and the State dare not interfere. What can be done? The Archbishops' Committee says the State must pay the teachers. This means Civil Service for the teachers, and handing over the appointment and dismissal of the teachers to the State. Voluntary teachers won't object to this, but the managers will, I fear.

THIS is in the far distant future, there can be no doubt. Even the Archbishops' Committee acknowledge this when they say:—'But it is obvious that it will take time to obtain relief in this way. No mistake would be greater than to place our sole reliance on the speedy success of such a proposal as this.' What about the present solution? The committee make three suggestions for immediate relief. P. T. centres to be open to voluntary school pupil teachers; relief from local rates; and greater generosity of wealthy Churchmen.

TAKE the Pupil Teacher Centre question. In Bolton the centre is open without charge to all pupil teachers, Board and Voluntary. Few of the voluntary schools can take advantage of the Board's provision. To release the pupil teachers means increasing the staff, which means increasing the expenditure, which in most cases means running into debt. This is true of large schools of over 600 in average attendance. But what about the more numerous schools of from 50 to 250 average? Too often the only staff beyond the head consists of pupil teachers. How are these to be released? Perhaps one of the Archbishops will practically demonstrate! Suggestion No. 1 looks better on paper than in actual practice.

RELIEF from local rating is a more tangible and therefore a more practical suggestion, but it means little. The relief could only be demanded for the School Board rate. Suppose the school is assessed at £100 a year, and the School Board rate is one shilling, this would just mean a five-pound note saved every year for a school capable of accommodating

five or six hundred scholars. Not a very great sum for so great a necessity. But taking the relief to extend to the whole of local taxation, the relief is totally inadequate. Take a concrete example. The Bolton School Board took 15s. 9d. from the rates for each child in average attendance last year, and paid for rents, rates, taxes, and insurance, 1s. 6¾d. per unit in average attendance. To bring the voluntary schools on the same footing :—

| | s. | d. |
|---|---|---|
| Amount per unit required - | 15 | 9 |
| „ „ „ obtained by rates, taxes, and insurance | 1 | 6¾ |
| Amount still required - - | 14 | 2¼ |

Relief from local rates is a mere drop in the ocean hardly worth serious consideration.

THE fourteen shillings is to be left to the generosity of wealthy Churchmen. Wealthy Churchmen are generally paying large sums in local taxation. As business men they are not easily moved by appeals to their religious enthusiasm. Many of them have long since failed to see the necessity for the continuance of the conflict, and appeals are made in vain. The report of the Archbishops' Committee lays bare the bitter necessity of the voluntary schools, but does little save express pious opinions to ameliorate their position. How long will the leaders of the Church continue to imagine a vain thing? Voluntary teachers are struggling under serious disabilities. If the Church cannot maintain her schools fully, then it is useless to continue the struggle.

THAT Inspectors rarely grasp the possibilities of the scholars in the lower standards is beyond doubt. One Inspector, whom Mrs. Malaprop would designate 'A progeny of learning,' spends half-an-hour describing the molecules of a liquid, and another arranging a series of Object Lessons for the First and Second Standards, that might well be divided into three sections and labelled physiology, physiography, and geology, Stage I and part of Stage II. But perhaps the Inspector who put the following to the First and Second Standards in a school taking Elementary Science as a Class Subject more fully exhibited his knowledge of the powers of children :—

1. Why are reptiles and fishes cold-blooded animals?
2. How many kinds of toads are there, and tell me their names?
3. Name the different kinds of frogs.

But 'The elegant simplicity of the three per cents' pales before the following for the Upper Standards :—

1. Which of the internal organs can be dispensed with?

'With too much thinking to have common thought,' the scientists of the Third Standard were set to solve the following queries :—

1. Name and describe the common snails.
2. How do slugs breathe?

I remember a friend of mine who took to slugs. It is one of those out-of-the-way studies — 'You lose it in the moment you detect.' Fired with a natural ambition to engross us in slugs, he spared neither ink, paper, nor time. He introduced slugs into every corner of our Debating Society, every member of which,

While memory holds a seat
In this distracted globe, remembers slugs.

TEACHERS are cognisant of the forces allied against them in fairly and freely classifying their scholars. In this matter, perhaps, one of the worst School Boards has been the Kingston-upon-Hull School Board. Hitherto the right has hardly existed except in name. All standards above the third were individually examined, and the teacher was not allowed to deviate from the schedule. The old order existed, except that the position was aggravated by the absence of the Exemption Schedule. In the lower standards the Board Inspector examined at the beginning of the school year, and settled the classification for the year. A public meeting was held in Hull just before Christmas. Mr. Macnamara exposed the unholy arrangement, and the Board has rescinded all previous resolutions on classification, and decided 'That the head teachers of the Board Schools be permitted to classify their scholars as they may deem best, subject to the approval of the Board's Inspector.' Better days are in store for Hull teachers. I congratulate the Board and the teachers.

THERE is just one thought on this question of classification. At present the managers are responsible for the classification. But if the classification has been defective, and therefore interfered with the progress of the school, the report suffers, which means that the teacher suffers. Ought not the blame to rest on the proper shoulders? Where the teacher is fettered by regulations like those that have pertained under the Hull School Board, ought not the Inspector to state in the report that the managers and not the teachers are the offenders. In many Voluntary Schools the teachers are cribbed, cabined, and confined by the interference of the managers. Why should all the blame rest on the teachers?

'SALARY Saturday' draws near. The suggestion of Mr. Jackman at the Nottingham Conference will do much to make Mr. Allen Croft's presidency of the Federation a record one. Much good must accrue from the simultaneous ventilation of the grievances of the Class Teachers. I hope the initial effort will be as successful as it deserves to be.

I HAVE to acknowledge a contribution from Miss Selvage to the Bolton Bazaar. Many thanks! I hope there are many other contributions on the way to St. James's, Bolton. To L.T., M.S.W., O.A.L., and S.R. I have to return thanks for missives, and to a number of readers of 'Notes and Notions' who sent me the season's greetings. My good wishes.

THE hearty congratulations of every teacher are Sir William George Kekewich's. By conferring the knighthood, Her Majesty has paid a fitting and appropriate tribute to a distinguished servant. But it is not service to the State that more directly moves the teachers. It is because Sir William is associated with the best traditions of the Education Department that teachers join in a pæan of praise that is as sincere as it is unanimous. How much of our educational reform of the last few years is due to the wide and generous sympathies of the Permanent Secretary, only Sir W. Hart Dyke and Mr. Acland can tell, but some of us recognise that the presence of Sir William is a security for progress.

# MODEL ANSWERS TO QUESTIONS SET AT THE QUEEN'S SCHOLARSHIP EXAMINATION,

DECEMBER 1894.

## ARITHMETIC.—MEN AND WOMEN.

Wednesday, December 19, 10 to 12.30.

### SECTION I.

1. Explain the following terms:—Measure, Multiple, Average, Percentage, Consols, Interest, Discount.

A *measure* of a quantity is a quantity which will divide into the given quantity an exact number of times. Thus 3 is a measure of 24, as it will divide it exactly 8 times.

A *multiple* of a quantity is a quantity which contains the given quantity an exact number of times. Thus 16 is a multiple of 4, as it contains it exactly 4 times.

The *average* of a number of quantities is the result we obtain by dividing the sum of the quantities by the number of quantities. Thus the average of the quantities 3, 4, 6, 7,

$$= \frac{3+4+6+7}{4} = \frac{20}{4} = 5.$$

A *percentage* of a quantity is a portion of it calculated at a certain rate for each 100 units contained in the quantity. Thus 14 per cent. on 1650 = $14 \times 16\frac{1}{2}$, because there are $16\frac{1}{2}$ hundreds in the quantity of which we take the percentage.

*Consols*, or Consolidated Annuities, are the debt owing by the British Government. The name is derived from the fact that loans contracted at various times have been consolidated into one.

*Interest* is the consideration paid for the use of money. Thus the Post Office Savings Bank pays the depositors in it £2 10s. each year for the use of each £100 lent to it.

*Discount* is the consideration paid to a broker or a bank for cashing a bill before it becomes due. The same term is also applied to the deduction which is made from the marked price of an article to a buyer who pays cash.

2. Divide 10,076 by 105, using the method of factors and short division, and explain clearly, as to a class of children, the value of each remainder.

$$105 = 3 \times 7 \times 5.$$

3)10,076

7)3,358 threes + 2 units

5)479 twenty-ones + 5 threes.

95 one-hundred-and-fives + 4 twenty-ones.

The result of the first step shows that in 10,076 there are 3,358 threes with 2 units remaining. Dividing 3,358 threes by 7, we get 479 twenty-ones, since $7 \times 3 = 21$, and 5 threes remaining. We now divide 479 twenty-ones by 5. The result is 95 one-hundred-and-fives, since $21 \times 5 = 105$, and 4 twenty-ones remaining. The full remainder = 2 units + 5 threes + 4 twenty-ones

$$= 2 + (5 \times 3) + (4 \times 7 \times 3) = 2 + 15 + 84 = 101.$$

3. Show that if two numbers are divided by their G.C.M., the quotients are prime to each other.

The G.C.M. of two numbers is the *greatest* number which will divide each of them without a remainder. Suppose now, after dividing each of the numbers by their G.C.M., we should find that each of the quotients so obtained is divisible by 2. It is evident, therefore, that instead of dividing the two numbers by 1st, their G.C.M., 2nd, the quantity 2, we might have made but one division, and divided both the quantities at once by *twice their G.C.M.* But this is impossible, since by the supposition the G.C.M. is the *greatest quantity* which will divide each of the given quantities. The quotients are therefore prime to each other.

4. In what way can the process in subtraction, erroneously called 'borrowing and carrying,' be justified?

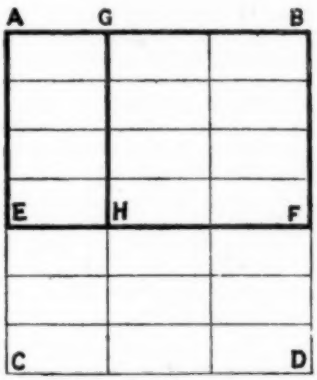
The result obtained by taking one quantity from another is the same as that obtained by adding to each of the quantities equal quantities, and then subtracting the less from the greater. Thus 6 from 9 produces the same result as 9 from 12, since each of these two last quantities is 3 more than the corresponding original quantity. Now when we take 15 from 32, we borrow 10, that is, we add 10 to the top quantity. We then pay back 1, that is, we add to the 1 of 15. But the 1 of 15 is really 10. What we really do, then, is to add 10 to the bottom quantity. As we have added 10 to each quantity the value of our result remains the same.

$$\begin{array}{r} 32 \\ 15 \\ \hline 17 \end{array}$$

5. Show by a diagram that $\frac{1}{3}$ of $\frac{4}{7} = \frac{4}{21}$.

Draw an oblong ABCD.

Divide the side AC into seven equal divisions, and through each of the divisions draw lines across the figure parallel to AB or CD.




The smaller oblongs thus formed are equal to each other, and since seven of them make up the whole figure, each equals $\frac{1}{7}$. Since AEFB contains four of these smaller oblongs, it = $\frac{4}{7}$ of the whole. Now divide AB into three equal parts, and draw lines parallel to AC or BD. We have now divided the figure into 21 equal parts. Each of them, therefore, = $\frac{1}{21}$ of the whole. The figure AEFB, which we have shown to be equal to $\frac{4}{7}$ of the whole, contains 12 of these smaller divisions.

The figure AEHG, which contains four of these smallest oblongs, or $\frac{4}{21}$, is therefore $\frac{1}{3}$ of $\frac{4}{7}$. It is also obvious that AEFB, which we have shown to be equal to $\frac{4}{7}$, is made up of three oblongs, each equal to AEHG.

AEHG, which contains $\frac{4}{21}$, is therefore $\frac{1}{3}$ of $\frac{4}{7}$.

6. If we add cyphers to the end of a decimal fraction, the value of the fraction is unaltered; but if we add cyphers at the end of a whole number, the value of the number is changed. Explain this as to a class of children.

*First Case—*

$$\cdot 23 = \frac{23}{100}.$$

Now add two cyphers to the end of the decimal fraction, making it ·2300.

$$\cdot 2300 = \frac{2300}{10000} = \frac{23 \times 100}{100 \times 100}.$$

We have here multiplied both numerator and denominator of the decimal fraction by 100. If we multiply both numerator and denominator of a fraction by the same number, the value of the fraction is unaltered.

*Second Case—*

If to the whole number, 23, we add two cyphers, we make it 2,300. In 23, since the 2 is in the *second* position going to the left, it = 2 *tens*. The 3, being in the position farthest to the right, = 3 *units*.

In 2,300 the 2 is now in the *fourth* position. Every time we shift a number one place to the left, we multiply its original value by 10. As we have shifted the 2 *two places* to the left, we have multiplied its original value by 100. It therefore equals now 2 *thousands*. The 3 has also been shifted two places to the left. Its value is now 100 times what it was before; that is, instead of being equal to 3 *units*, it is now equal to 3 *hundreds*.

### SECTION II.

7. Find the L.C.M. of 7, 8, 9, 18, 24, 72, and 144.

7, 8, 9, ~~18~~, ~~24~~, ~~72~~, 144.

We strike out 8, 9, 18, 24, 72, because each of them is contained in 144. We have now left only 7 and 144. Since these have no common factor, the L.C.M. of all the numbers is got by multiplying them together.

$$\text{L.C.M.} = 7 \times 144 = 1008.$$

8. Reduce £1·5 + 1·5s. + 1·5d. to the decimal of £6 6s. 6d.

£1·5 = 240d. × 1·5 = 360 pence.
1·5s. = 12d. × 1·5 = 18 pence.
1·5 pence.
The total in pence = 379·5 pence.
£6 6s. 6d. = 1518 pence.

$$\frac{379\cdot5}{1518} = \frac{3795}{15180}.$$

3795 is the G.C.M. of both numerator and denominator. Dividing both numerator and denominator by this:

$$\frac{3795}{15180} = \frac{1}{4} = \cdot25, \text{ the decimal required.}$$

9. Simplify $\dfrac{\frac{5}{7} \text{ of } \frac{3}{10} + \frac{1}{4} \text{ of } \frac{8}{21}}{\frac{5}{7} \text{ of } \frac{3}{10} - \frac{1}{4} \text{ of } \frac{8}{21}}$.

Simplify the numerator:

$$\frac{5}{7} \text{ of } \frac{3}{10} + \frac{1}{4} \text{ of } \frac{8}{21}$$
$$= \frac{5 \times 3}{7 \times 10} + \frac{1 \times 8}{4 \times 21}$$
$$= \frac{3}{14} + \frac{8}{21}$$
$$= \frac{9 + 4}{42} = \frac{13}{42}.$$

Simplify the denominator:

$$\frac{5}{7} \text{ of } \frac{3}{10} - \frac{1}{4} \text{ of } \frac{8}{21}$$
$$= \frac{3}{14} - \frac{8}{21}$$
$$= \frac{9 - 4}{42} = \frac{5}{42}.$$
$$\frac{13}{42} \div \frac{5}{42} = \frac{13}{42} \times \frac{42}{5} = \frac{13}{5} = 2\frac{3}{5}.$$

10. If 3 men mow a field of $4\frac{1}{2}$ acres in 2 days of 8 hours each, in how many days of 9 hours each will 11 men mow a rectangular field 330 yards long, and 198 yards broad.

Area of field to be mown = (330 × 198) sq. yds.

In 1 ac. are 4,840 sq. yds.

No. of ac. to be mown $= \dfrac{330 \times 198}{4840}$. Cancelling by 11

$$= \frac{3 \times 198}{44} \text{ ac.} \quad \text{Cancelling by 22}$$
$$= \frac{3 \times 9}{2}, \text{ or } 13\tfrac{1}{2} \text{ ac.}$$

Now stating the sum by Compound Proportion:

9 : 8 :: 2 days
11 : 3
$4\frac{1}{2}$ : $13\frac{1}{2}$.

$$\frac{2 \text{ d.} \times 8 \times \cancel{3} \times 13\frac{1}{\cancel{2}}}{\cancel{9} \times 11 \times \cancel{4\frac{1}{2}}_{\cancel{3}}} = \frac{16}{11} \text{ d.} = 1\tfrac{5}{11} \text{ d.}$$

11. A road is 10,000 metres long. Express its length in miles, yards, and feet; a metre being equal to 39·3708 inches.

10,000 metres = (39·3708 × 10,000) inches
= 393708 inches.

12)393708 inches.
3)32809 feet.
10936 yds. 1 ft. length of the road = 6 mi. 376 yds. 1 ft.

12. Find, by Practice, the value of 3,825 articles at £2 17s. $4\frac{1}{2}$d. each.

| £ | s. | d. | |
|---|---|---|---|
| 3825 | 0 | 0 | value of the articles at £1 each. |
| | 2 | | |
| 7650 | 0 | 0 | value at 2 0 0 each. |
| 1912 | 10 | 0 | value at 10 0 each. |
| 956 | 5 | 0 | value at 5 0 each. |
| 382 | 10 | 0 | value at 2 0 each. |
| 47 | 16 | 3 | value at 3 each. |
| 23 | 18 | 1½ | value at 1½ each. |
| 10972 | 19 | 4½ | value at 2 17 4½ each. |

| s. | d. | |
|---|---|---|
| 10 | 0 | = ½ of 1£ |
| 5 | 0 | = ¼ of 10s. |
| 2 | 0 | = ⅕ of 10s. |
| 3 | | = ⅙ of 2s. |
| 1½ | | = ⅛ of 3d. |

13. In what time will a sum of money be doubled at $1\frac{1}{4}$ per cent. simple interest?

The problem is to find out in what time, at the given rate of interest, £100 will produce £100 interest.

£100 produces £1¼ interest in 1 year.

£100 ,, £1 ,, ,, $\frac{1}{1\frac{1}{4}}$ years.

£100 ,, £100 ,, ,, $\frac{1 \times 100}{1\frac{1}{4}}$ years
= 80 years.

14. If I invest £7,927 10s. in 3 per per cent. stock, at $94\frac{3}{8}$, what annual income shall I receive from the investment, after deducting an income tax of 6d. in the pound?

Gross income on an investment of £$94\frac{3}{8}$ = £3.
,, ,, ,, ,, ,, £1 = £$\frac{3}{94\frac{3}{8}}$.
,, ,, ,, ,, ,, £7927½ = £$\frac{3 \times 7927\frac{1}{2}}{94\frac{3}{8}}$.

$$\frac{£3 \times 7927\tfrac{1}{2}}{94\tfrac{3}{8}} = £3 \times 7927\tfrac{1}{2} \div 94\tfrac{3}{8}$$
$$= £3 \times \frac{15855}{2} \div \frac{755}{8}$$
$$= £\frac{3 \times 15855 \times \overset{4}{8}}{\underset{1}{2} \times 755} \quad (15855 = 755 \times 21)$$
$$= £3 \times 21 \times 4 = £252.$$

Tax on £252 = 6d. × 252 = £6 6s.
Net annual income = £252 − £6 6s.
= £245 14s.

## Section III.

15. What is the G.C.M. of £36 0s. 4½d., £48 14s. 7½d., and £86 17s. 4½d.?

£36 0s. 4½d. = 17,289 halfpence.
£48 14s. 7½d. = 23,391 halfpence.
£86 17s. 4½d. = 41,697 halfpence.

17289)23,391(1
17,289
6,102)17,289(2
12,204
5,085)6,102(1
5,085
1,017)5,085(5
5,085

1,017 is the G.C.M. of 17,289 and 23,391. The G.C.M. of 1,017 and 41,697 will be the G.C.M. of the three numbers.

1017)41697(41
4068
1017
1017

1,017 halfpence is the G.C.M. of 17,289 halfpence, 23,391 halfpence, and 41,697 halfpence.

1,017 halfpence = £2 2s. 4½d.
∴ £2 2s. 4½d. is the G.C.M. of the three sums of money given.

16. After spending ½ of ⅔ of ¼ of the money in my purse, I find that I have just enough left to buy $9\frac{3}{4}$ dozen eggs at the rate of 4 for 3d.; how much money was in my purse at first?

$$\tfrac{1}{2} \times \tfrac{2}{3} \times \tfrac{1}{4} = \tfrac{1}{12}.$$
$$1 - \tfrac{1}{12} = \frac{35 - 6}{35} = \tfrac{29}{35} \text{ fraction of my money I have left.}$$
$9\frac{3}{4}$ dozen = 116.
4 eggs cost 3d.
∴ 1 egg costs ¾d.
∴ 116 eggs cost $\dfrac{3 \times 116}{4}$d. = 87d.
∴ $\frac{29}{35}$ of my money = 87d.
∴ $\frac{1}{35}$ of my money = $\frac{87}{29}$ = 3d.
∴ $\frac{35}{35}$ of my money = 3d. × 35 = 8s. 9d.

17. A walks at the rate of 4 miles an hour, and goes a certain distance in 30 minutes less than B, who walks the same distance at the rate of 3 miles an hour; what is the distance?

A walks 4 m. in 60 min., or 1 m. in 15 min.
B walks 3 m. in 60 min., or 1 m. in 20 min.
∴ To gain 5 min. on B, A must walk 1 m.
∴ ,, 1 min. ,, ,, ,, $\frac{1}{5}$ m.
∴ ,, 30 min. ,, ,, ,, $\frac{1 \times 30}{5} = 6$ miles.

Ans. 6 miles.

18. The surface of a chess-board is taken up by a rim $1\frac{1}{2}$ inches wide, running along each of the four sides, and by 64 equal squares. If the side of one of these squares is 2 inches long, find the area of the rim.

If there are 64 squares in all, there must be $\sqrt{64}$, or 8 squares in a row.

The length and width of the board each = 8 times the length of a side of one of the squares + twice the width of the rim, since the rim is on *each* side of the board.

∴ Length of one side of the board = 2 in. × 8 + $1\frac{1}{2}$ in. × 2 = 16 in. + 3 in. = 19 in.

Total area of board = 19 in. × 19 in. = 361 sq. in.
Total area of the squares = 2 in. × 2 in. × 64 = 256 sq. in.
Area of the rim = total area — area of squares
= 361 sq. in. — 256 sq. in. = 105 sq. in.

19. A cricketer who bats and is out on 20 occasions, has an average of 34 runs for 17 innings; he then makes 14 and 6 runs respectively, and in his last innings makes enough runs to give him an average of 35 for the whole season. How many runs did he make at his last attempt?

Total runs for 20 innings = 35 × 20 = 700.
,, ,, 17 innings = 34 × 17 = 578.
,, ,, last 3 innings = 700 − 578
= 122
Total runs for 18th and 19th innings
= 14 + 6 = 20.
∴ Total runs for the last innings
= 122 − 20 = 102.

20. If the ratio of the circumference of a circle to its diameter be as 355 to 113, how many times will a carriage wheel whose diameter is 4 feet revolve in a distance of 4 miles 1,480 yards?

4 m. 1,480 yds = 25,560 ft.

$$\text{Circum. of wheel} = \frac{4 \text{ ft.} \times 355}{113} = \frac{1,420}{113} \text{ ft.}$$

∴ Number of revolutions made by the wheel

$$= 25,560 \div \frac{1420}{113} = \frac{\overset{18}{\cancel{25560}} \times 113}{\underset{1}{\cancel{1420}}} = 2,034.$$

21. If 3 articles are sold for the cost price of 4, what is the rate of gain per cent.?

By the sale of 3 articles, 1 article is gained.
,, ,, 1 article, $\frac{1}{3}$ ,, ,,
,, ,, 100 articles, $\frac{1 \times 100}{3}$ articles are gained.

∴ Gain per cent. = $\frac{100}{3}$, or $33\frac{1}{3}$.

22. Having invested equal sums in a 4 per cent. stock at 85, and a 5 per cent. stock at 95, I find that the difference in the income from the two investments amounts to £260; how much did I invest in each stock?

In 1st investment, £85 produces £4 interest.
∴ ,, ,, £1 ,, £$\frac{4}{85}$ ,,
∴ ,, ,, £100 ,, £$\frac{4 \times 100}{85}$ ,,

$$£\frac{4 \times \overset{20}{\cancel{100}}}{\underset{17}{85}} = £\frac{80}{17} = £4\frac{12}{17}.$$

In 2nd investment, £95 produces £5 interest.
∴ ,, ,, £1 ,, £$\frac{5}{95}$ ,,
∴ ,, ,, £100 £$\frac{5 \times 100}{95}$.

$$£\frac{5 \times 100}{\underset{19}{95}} = £\frac{100}{19} = £5\frac{5}{19}.$$

Difference in income on an investment of £100 in each of the two stocks respectively = £$5\frac{5}{19}$ − £$4\frac{12}{17}$

$$= £\frac{100}{19} - £\frac{80}{17} = £\frac{1700 - 1520}{323} = £\frac{180}{323}.$$

To produce difference in income of £$\frac{180}{323}$ requires an investment of £100.

To produce difference in income of £1 requires an investment of £100 ÷ $\frac{180}{323}$.

To produce difference in income of £260 requires an investment of £100 ÷ $\frac{180}{323}$ × 260.

$$£100 \div \frac{180}{323} \times 260 = £\frac{\overset{5}{\cancel{100}} \times 323 \times 260}{\underset{9}{\cancel{180}}} = \frac{419900}{9}$$

= £46,655 11s. $1\frac{1}{9}$d.

Ans. £46,655 11s. $1\frac{1}{9}$d.

## GRAMMAR AND COMPOSITION.

Wednesday, December 19, 2.30 to 5.

1. Write a short essay on *one* of the following subjects:—

(*a*) 'Words are like leaves; and when they most abound,
Much fruit of sense beneath is rarely found.'

(*b*) Your favourite pursuit.

(*c*) Christmas Day on board an English ship in the Polar Regions.

(*a*) The quotation refers to a fact connected with the growth of trees which has often been remarked on. When a tree produces a particularly abundant crop of leaves, it is by no means uncommon to find that the size and quantity of the fruit are below the average. The tree, in fact, seems to have exhausted its energy in producing its ornament of leaves, and thus to have been unable to produce in sufficient fulness the useful fruit. It is often thus with speakers and writers. High sounding words and harmony of expression often conceal poverty of thought. The manner in which he shall present his ideas to the world has occupied the author's mind to the neglect of the matter. We rise from the perusal of a book which exhibits the fault referred to in the quotation with a feeling that what we have learned does not repay us for the time we have given to it. Once read, such a book is never again opened. But the case is far different with a book in which the ideas to be presented are the main concern of the author. A book of this kind hardly contains one word which could be spared. The closest attention must be given to it in order to grasp the full meaning of what we have read. Our ideas become enlarged, new lights are thrown on points which have hitherto not been clear to us, and we read and re-read, discovering something new at every fresh perusal. The essays of Lord Bacon furnish a very good example of a work of this character.

But it is not only in speaking and writing that a multitude of words serves to hide a poverty of thought. In conversation the person who talks at greatest length does not always add the most to the enjoyment of those with whom he is conversing. It is far oftener the case that a person who takes but little part in conversation makes a better contribution to the subject under discussion than many a more voluble and fluent speaker.

2. Analyse the following passage, and parse the words in italics:—

'It is an *isle* under Ionian skies,
Beautiful *as* a wreck of Paradise.
And, *for* the harbours are not safe and good,
This land *would have remained* a solitude
*But for* some pastoral people *native* there,
*Who* from the Elysian, clear, and golden air
Draw the last spirit of the age of gold,
Simple and spirited, innocent and bold.'

*Sentences with their relationships to each other.*

Complex Sentence.
(*a*) It is an isle under Ionian skies beautiful. Prin. sent. to (*b*), co-ordinate with (*c*).
(*b*) As a wreck of Paradise. Contracted Adverb. sent. of comparison to (*a*).

Complex Sentence.

(*c*) And this land would have remained a solitude but for some pastoral people native there. Prin. sent. to (*a'*) and (*e*).

(*d'*) For the harbours are not safe and good. Adverb. sent. of reason to (*c*).

(*e*) Who from the Elysian, clear, and golden air draw the last spirit of the age of gold, simple and spirited, innocent and bold. Adj. sent. to (*c*), referring to 'people.'

(The whole forms a compound sentence, made up of the two complex sentences *a–b* and *c–d–e*.)

| Number of Sentence. | Connecting word. | Subject. | | Predicate. | | | |
|---|---|---|---|---|---|---|---|
| | | Simple Subject. | Enlargement of Subject. | Simple Predicate. | Completion of Predicate. | | Extension of Predicate. |
| | | | | | Copulative. | Objective. | |
| (*a*) | | It | | is | an isle beautiful | | under Ionian skies (place) |
| (*b*) | as | a wreck | of Paradise | (is) | (beautiful) | | |
| (*c*) | and | this land | | would have remained | a solitude | | but for some pastoral people native there |
| (*d'*) | for | the harbours | | are | safe and good | | not (negation) |
| (*e*) | | who | simple and spirited, innocent and bold | draw | | the last spirit of the age of gold | from the Elysian, clear, and golden air (place) |

*isle*, noun, com., 3rd pers., sing. numb., neut. gend., nom. case, in apposition with 'it.'

*as*, subordinative conjunction, joining the contracted sentence of comparison, 'a wreck of Paradise,' to the sentence 'It is an isle under Ionian skies.'

*for*, subordinative conjunction, joining the adverbial sentence of reason, 'the harbours are not safe and good,' to the sentence, 'and this land, etc.'

*would*, verb, strong, indic. mood, past tense, sing. numb., 3rd pers., agreeing with its nominative 'land;' auxiliary 'to have.'

*have*, verb, strong, infinitive mood, depending on the auxiliary 'would'; auxiliary to 'remained.'

*remained*, past part. of the weak, intrans. verb 'to remain,' depending on the auxiliary 'have.'

*would have remained*, perfect form of the verb 'to remain,' expressing the consequence of the conditional expression, 'But for some pastoral people native there.'

*but for*, compound preposition, showing the relationship of 'people' to 'remain.'

*native*, adj. of qual., referring to 'people.'

*Who*, rel. pronoun, 3rd pers., plur. numb., com. gend., agreeing with its antecedent 'people'; nominative to 'draw.'

3. Give a simple paraphrase of the following passage:—

'Above me are the Alps,
The palaces of Nature, whose vast walls
Have pinnacled in clouds their snowy scalps,
And throned eternity in icy halls
Of cold sublimity, where forms and falls
The avalanche—the thunderbolt of snow!
All that expands the spirit, yet appals,
Gathers around these summits, as to show
How earth may pierce to heaven, yet leave vain man below.'

The Alps extend above me their lofty cloud-piercing heights. These masterpieces of Nature's handiwork far outrival the palaces which man builds, for their lofty walls, which will last as long as this earth lasts, extend even to the clouds. On their heights are formed the avalanches which roll down their sides with the noise and more than the destructiveness of the thunderbolt. The immense scale on which Nature has worked in forming these lofty mountains expands, whilst it appals, the mind. Whilst these lofty summits seem to show us that heaven may be reached from earth, they humble poor weak man, who in gazing upwards to them feels that they are the production of a power infinitely superior to his own.

4. Distinguish between the meaning of the following words, and use each of them in an appropriate sentence.

1. *Allusion*, a reference in speaking or writing to some event or fact.
He made no *allusion* to his recent illness.

*Illusion*, a deception of the senses or the judgment.
A nearer approach to the object convinced me that I had been the victim of an *illusion*.

2. *Compliment*, a pleasing or flattering reference to something.
I felt I had done nothing to deserve such a *compliment*.

*Complement*, something which completes.
The ship will sail when it receives its full *complement* of men.

3. *Continual*, which never ceases.
The Deity exercises a *continual* care for all His creatures.

*Continuous*, without break.
A *continuous* line of carriages extended from the palace to the park.

4. *Deference*, submission to the opinion or judgment of another person.
He showed little *deference* for the opinions I had expressed.

*Difference*, unlikeness.
There is a great *difference* between teaching and being taught.

5. *Influence*, power which one person exerts over another by virtue of superiority in station, wealth, age, character, or knowledge, etc.
He exercised so much *influence* over his fellow-townsmen that he succeeded in inducing them to adopt his plan.

*Affluence*, a state of abundance or wealth.
He lived for some years in great *affluence*.

6. *Luxuriant*, of abundant growth.
The foliage of these trees is *luxuriant*.

*Luxurious*, indulging in luxury of dress, food, etc.
His manner of living was most *luxurious*.

7. *Prosecute*, to endeavour to secure the conviction of a person alleged to have broken the law.
One of the most prominent solicitors in the town attended to *prosecute* the prisoner.

*Persecute*, to endanger a person's life, or render it unhappy, by maliciously taking every opportunity of causing him trouble or annoyance.
The Russian Government has ceased to *persecute* the Jews.

8. *Sufferance*, permission which may be withdrawn at any time.
Visitors are allowed to enter Lord R.'s woods only on *sufferance*.

*Suffering*, feeling of pain, or agony of body or mind.
I cannot describe to you the *suffering* which I endured.

9. *Urban*, belonging to a town.
The *Urban* District Councils have just been elected.

*Urbane*, courteous in manner and speech.
Our host was a most *urbane* man.

5. Quote a passage, not exceeding ten lines, from any standard English poet (excluding Shakespeare and Milton) that you consider especially noteworthy on account of beauty of diction, and justify your selection by adequate reasons.

*From a sonnet by Wordsworth.*

Milton! thou should'st be living at this hour,
England hath need of thee; she is a fen
Of stagnant waters; altar, sword, and pen,
Fireside, the heroic wealth of hall and bower,
Have forfeited their ancient English dower
Of inward happiness. We are selfish men!
Oh! raise us up; return to us again;
And give us manners, virtue, freedom, power.
Thy soul was like a star, and dwelt apart,
Thou hadst a voice whose sound was like the sea.

The whole of this sonnet is a most beautiful production, and, like all masterpieces of language, its beauty almost defies analysis. It should be pointed out how powerful an indictment against England, as it was when this sonnet was written, is compressed into a few lines. The short phrase, 'a fen of stagnant waters,' paints in striking colours our country as she appeared to the apostle of 'plain living and high thinking,' whilst the simple words 'altar, sword, pen,' suggest the apathy of the Church, the debasement of literature, and the need of reform in the Army. The similes in the last two lines most beautifully suggest the austere character and great influence of Milton.

6. Comment on the words given below, giving illustrations where you can of similar grammatical forms:—'afoot,' 'yclept,' 'twain,' 'chode,' 'kine,' 'gotten,' wot,' 'hindmost.'

*afoot.*—Prefix *a* = on, so that afoot = on foot. Compare aboard, afloat, ashore.

*yclept* is from the old verb *clypian*, 'to call.' The *y* is a weakened remnant of the old past participle prefix *ge*. This prefix still exists in German (*e.g.*, *lieben*, to love; *geliebt*, loved). Compare *ymade* = made (Chaucer). A modern imitation is Shelley *star-y-paven*, that is, paved with stars.

*twain*, two. From the A.S. *twegen*, the masculine form for two. Other words having the same root are *twine*, *twin*, *twig*, be-*tween*.

*chode*, formerly the preterite of *chide*. Many verbs which are now weak, were originally strong. With *chide*, *chode*, compare *ride*, *rode*.

*kine*, an instance of a double plural. The A.S. word for cow was *cu*, the plural of which, formed by vowel change, was *cy*. To this the plural termination *n* was added, under the impression that *ky*, the middle English for *cy*, was a singular. Another instance of double plural is *children*.

*gotten*, the old past participle of get. Compare *trodden*, *hidden*.

*prithee* = I pray thee. Compare quotha = quoth he.

*wot*, 3rd pers. sing. pres. tense of the Middle English verb *witen*, 'to know.' Afterwards looked upon as a preterite, and so used.

*hindmost*. The *-most* here is formed by a combination of two superlative endings *-ema* and *-est*. After the meaning of the first termination was forgotten, the second was mistakenly added. A similar word is *foremost*.

7. Explain by their etymology, so as to be intelligible to the first class of a senior school, the names of each of the parts of speech.

*Article* from L. *articulus*, a small joint. It thence came to be applied to the insignificant words which introduce and accompany nouns.

*Noun* from L. *nomen*, a name. A noun is a word used as the name of something.

*Adjective* (L. *adjicio*, I add to). An adjective is so-called because it is *added* to a noun to define it more accurately.

*Pronoun* (L. *pro*, instead of; *nomen*, a name). Without being itself used as a name, a pronoun stands instead of a word used as a name.

*Verb* (L. *verbum*, word). The verb is the all-important *word* of a sentence, as by it we are enabled to *affirm* or *state* the idea we intend to convey.

*Adverb* (L., *ad* to, and *verbum*, word or verb). An adverb is a word used to modify attributive words, that is, verbs, adjectives, and adverbs themselves. As it is mainly used to modify verbs, it was called *adverb*, which means 'joined or added to a verb.'

*Preposition* (L. *præ*, before; *positio*, a placing). The preposition is so called because it is, as a rule, placed *before* a noun or pronoun to show the relation of the thing for which it stands to the idea expressed by some other noun, pronoun, verb, or adjective in the sentence.

*Conjunction* (L. *con*, together; *junctio*, joining). A conjunction is a word which joins together words and sentences.

*Interjection* (L. *inter*, between; *jicio*, I throw). An interjection is so-called because it is, as it were, *thrown* in *between* the really significant words of a sentence. It does not really belong to the sentence at all, and cannot properly be placed under any of the divisions made in its analysis.

8. What classification of English adverbs is most satisfactory? Give some examples of each class.

The classification of adverbs which is most satisfactory is the following. Those of—

I. *Time*—1. *Simple*, as, now, never.
2. *Conjunctive* or *Relative*, as, when.
II. *Place*—1. *Simple*, here, there, hence.
2. *Conjunctive* or *Relative*, where, whence.
III. *Degree*, how, very, greatly.
IV. *Manner*, badly, well, ill.
V. *Cause*, why, wherefore.
VI. *Mood*, yes, no, certainly.

9. Chaucer has been called 'the finder of our fair language.' Illustrate and amplify this statement.

Chaucer is called 'the finder of our fair language,' because—

1. He was the first who wrote in an English which differs but little from the English of the present day, and can be read with but little trouble by a student of to-day.

2. He first showed the capabilities of English for elegant versification and agreeable prose.

3. He set up a standard of classical English which has substantially remained the standard for the present day.

4. He improved the metres used in English poetry before his time, and introduced new metres which have since been adopted by modern poets.

The following quotation from Chaucer, describing the Prioress of the Canterbury Tales, illustrates some of the remarks made above:—

'But for to speaken of her conscience
She was so charitable and so pitous (full of pity);
She wolde weep if that she saw a mouse
Caught in a trap, if it were dead or bled.
Of (some) smale (small) houndes had she that fed
With roasted flesh, and milk, and wastel bread (remnants of bread);
But sore wept she if one of them were dead,
Or if men smote it with a yerde (rod) smart:
And all was conscience and tender heart.'

## LATIN.

### Alternative Paper with English Grammar and Composition.

Wednesday, December 19, 2.30–5.0.

1. Translate:—

(1) Talia jactanti stridens Aquilone procella
Velum adversa ferit, fluctusque ad sidera tollit.
Franguntur remi; tum prora avertit et undis
Dat latus; insequitur cumulo praeruptus aquae mons.
Hi summo in fluctu pendent, his unda dehiscens
Terram inter fluctus aperit; furit aestus arenis.
Tres Notus abreptas in saxa latentia torquet;
Saxa vocant Itali mediis quae in fluctibus aras,
Dorsum immane mari summo; tres Eurus ab alto
In brevia et syrtes urget (miserabile visu)
Inliditque vadis atque aggere cingit arenae.

While he makes such laments, a howling blast strikes his sail in front with a north wind, and raises the waves as high as the heavens. The oars are broken. Then the prow swings aside and exposes the side (of the vessel) to the waves; there follows in a heap a towering cliff of water. Whilst some are suspended on the top of a wave, a yawning billow discloses to others the earth amidst the waters; the sea boils with sand. The south wind carrying three (ships) violently away, whirls them on to hidden rocks. The Italians calls the rocks which are in the midst of the sea 'altars'—an immense projection on the top of the waves. The east wind drives three (ships) from the deep into shallows and quicksands—a sight to excite pity. It dashes them into the shallow places and surrounds them with a heap of sand.

(2) O qui res hominumque deumque
Aeternis regis imperiis et fulmine terres,
Quid meus Aeneas in te committere tantum,
Quid Troes potuere, quibus tot funera passis.
Cunctus ob Italiam terrarum clauditur orbis?
Certe hinc Romanos olim volventibus annis,
Hinc fore ductores revocato a sanguine Teucri,
Qui mare, qui terras omni ditione tenerent,
Pollicitus: quae te, genitor, sententia vertit?
Hoc equidem occasum Troiae tristesque ruinas
Solabar fatis contraria fata rependens;
Nunc eadem fortuna viros tot casibus actos
Insequitur. Quem das finem, rex magne, laborum?

O thou who directest the affairs of gods and men with eternal sway, and terrifiest (them) with thy thunderbolt, what dreadful crime could my Æneas have committed against thee? what could the Trojans have done, to whom, after they have endured so many deaths, the whole circuit of the world is shut off to keep them from Italy? In truth thou didst promise, from them in the rolling years to come the Romans, sprung from the revived race of Teucer, should be leaders, to hold sea and land in universal sway. What idea, O father, turns thee from thy purpose? With this at least I was consoling myself for the fall and sad destruction of Troy, whilst I compared these contrary fates, and weighed one against another. Now the same ill fortune pursues men who have been subject to so many freaks of fortune. What end of troubles dost thou give, great king?

(3) Lucus in urbe fuit medea, laetissimus umbrae,
Quo primum jactati undis et turbine Poeni
Effodere loco signum, quod regia Iuno
Monstrarat, caput acris equi; sic nam fore bello
Egregiam et facilem victu per saecula gentem.
Hic templum Iunoni ingens Sidonia Dido
Condebat, donis opulentum et numine divae,
Aerea cui gradibus surgebant limina nexaeque
Aere trabes, foribus cardo stridebat aenis.

There was a wood in the middle of the city very rich in shade, in which place first of all the Carthaginians, after being tossed about by the waves and by the tempest, dug up an image which queenly Juno had pointed out, the head of a war-horse, for she said that so would the people be pre-eminent in war and rich in substance for all time. Here Sidonian Dido was building an immense temple to Juno, abounding in gifts and in the favour of the goddess. To this temple brazen thresholds were rising over the steps, and beams fastened with bronze, and the hinge was grating on the brazen doors.

Parse, fully:—praeruptus, potuere, monstrarat, passis, tenerent.

*praeruptus*, perf. part. pass. masc. s. of *prærumpo*, referring to *mons*.

*potuere*, pres. perf. ind. 3rd pl. of *possum* (*potui*, *posse*), agreeing in number and pers. with the compound subject *Æneas* and *Troes*.

*monstrarat*, contracted past perf. ind. 3rd s. of *monestrare* (*monstro*, *avi*, *atum*, are), agreeing in numb. and pers. with subj. Juno.

*passis*, perf. part. pass. dat. pl. mas. of *patior* (*patior*, *passus sum*), agreeing in gender and number with *quibus*.

*tenerent*, imperf. subj. 3rd pl. of *teneo* (*teneo*, *tenui*, *tentum*, *tenere*), agreeing in number and person with the subj. *qui*.

2. Translate into Latin :—

(1) Cæsar first comes into Britain, but he does not remain long in our island.

Cæsar primum in Britanniam venit, sed non diu in nostra insula manet.

(2) It is not the man whose riches are great, but he who is content with his lot, who is happy.

Non is, qui divitissimus est, sed is, qui sua sorte contentus est, beatus est.

(3) Then the king's forces, freed from all fear, make an attack upon the enemy.

Tum regis milites, omni pavore liberati, impetum in hostes faciunt.

(4) The king's forces had pitched their camp on one side, the barbarians on the other side, so that there was a valley between the two armies.

Regis copiæ hic, barbari autem illic, castra locaverant, quamobrem vallis inter duos exercitus fuit.

(5) Then Mucius says, 'I am a Roman citizen, and I do not fear the fire,' and at once he thrusts his right hand into the flame, and does not withdraw it as it burns.

Tum Mucius, Ego, inquit, civis Romanus sum, nec ignem timeo. Statim dextram manum in flammam trudit, nec eam ardentem abstrahit.

3. State generally the uses of the subjunctive mood in Latin, and give four short sentences to illustrate your statements.

The subjunctive mood is used in Latin:—

(1) After certain subordinative conjunctions, as *ut* (expressing purpose or consequence), *ne* (when it = lest), and *quin* (with negative verbs of doubting, and with verbs expressing hindering).

Roman ibit ut patrem videat.

(2) In simple or principal sentences to express a modified imperative, as,

Ne noceas illi puellæ.

(3) In dependent sentences and commands in the *oratio obliqua*.

Dixit se eum vidisse, qui equum emerit.

(4) In conditional clauses, when the verb in the principal sentence is in the subjunctive.

Si eum conveniam, rogem num pater hortum vendiderit.

4. Detail, as fully as you can, three similes occurring in Virgil, Æn. I., 1–500.

(1) In lines 148–156, Neptune is represented as calming the fury of the waves in the same way as, in the case of riot or sedition breaking out in a town, a man influential on account of his personal worth is able to calm the angry passions of the citizens.

(2) In lines 430 and the following, the busy toilers who are engaged in the various occupations required for building Carthage are compared to bees, who, too, have distinct duties. Some gather honey in the fields, others store it in the cells, others receive their loads from those who have been out foraging, or prevent the drones making depredations on the store of honey.

(3) In lines 497 to 500, Dido, coming to the temple, accompanied by her maidens, is compared to Diana exercising her companions on the banks of Eurotas or on the mountains of Cynthius.

5. Show how each of the following English complex or compound sentences may be translated into a simple Latin sentence (*i.e.*, without any dependent clause):—

(1) When he had spoken these words he went away.

(2) He gave a prize to all the boys who were industrious.

(3) He entered their country (fines) and killed the inhabitants.

(4) As he was unwilling to fight he dismissed his army.

1. By turning 'when he had spoken these words' into an ablative absolute phrase.

His dictis, abiit.

2. By turning 'all the boys who were industrious' into 'each industrious boy.'

Quemque solertissimum præmio donavit.

3. By turning 'He entered' into a perfect participle of a deponent verb.

Ingressus fines incolas interfecit.

4. By changing 'As he was unwilling' into a present participle.

Nolens pugnare exercitum dimisit.

6. State, in not more than ten lines, the circumstances which resulted in Æneas leaving his native land.

Æneas is represented by Homer as being the son of Anchises and Aphrodite, and the nephew of Priam, king of Troy. At

first, he took no part in the Trojan war, which had been provoked by the abduction of Helen by Paris. Being attacked by Achilles, he performs many deeds of valour for the Trojans, but is unable to avert the doom of the city. The Greeks capture Troy, and Æneas escapes by the help of the gods. With his companions he leaves Troy to find a new habitation elsewhere.

## SCHOOL MANAGEMENT.

Thursday, Dec. 20th, 9.30 to 11.30.

1. Write full notes of a lesson on one of the following subjects:—

(1) The Oak Tree. (For infants.)
(2) The Alps.
(3) The Revolution of 1688.
(4) The Pump.

NOTES OF A LESSON ON THE REVOLUTION OF 1688.

Class—Standard VI. Time—40 minutes.

I.—*Preliminary.*—Ask class what a revolution is. See if any of them are acquainted with revolutions of later times; *e.g.* the French Revolution of 1789. Lead them to see that revolutions are usually accompanied by bloodshed. Point out that bloodshed was avoided in the Revolution of 1688.

II.—*First Step.*—Causes.

(*a*) On the side of the Crown :—

(1) The belief in the doctrine of the 'divine right of kings.'

(2) James attempts to win back England to Roman Catholicism. Clergymen who were secretly Papists were promoted.

(3) James interferes with popular government by forcing towns to give up their charters and accept new ones, diminishing the powers of the municipalities.

(4) James exercises his dispensing power. The trial of the Bishops. Their acquittal.

(5) Narrow-mindedness and obstinacy of the King, who is unable to see that the people are against him.

(*b*) On the part of the people :—

(1) The growth of better ideas as to government.

(2) The growth of the power of the Commons and of the desire to secure popular freedom.

(3) The humiliating position into which England had fallen, as compared with the position she had reached during the Protectorate.

(4) The hatred and dread of Roman Catholicism.

III.—*Second Step.*—The Revolution.

Commenced by an invitation to Prince of Orange from many of the most prominent men of England to accept the throne. Landing of William. James marches against him. His troops, his officers, and his own daughter desert him. James tries to leave the country, is brought back, but makes a second attempt, this time successful, to escape. Is adjudged to have forfeited the crown, which is offered to William and Mary.

IV.—*Third Step.*—Results.

(1) Excluded Roman Catholics from the succession.

(2) Settled the questions of 'divine right' and the dispensing power.

(3) Enlarged the power of the Commons.

(4) Was instrumental in bringing about Religious Toleration, and, less directly, many modern reforms.

2. By what means have you been accustomed, when teaching children to read, to promote individual effort in dealing with new or forgotten words?

(1) By eliciting a *resumé* of that part of the lesson which precedes the difficult word, and hence getting the children to find out what the meaning of the word must be.

(2) By placing the word in an easy sentence of my own construction, and getting the class, from a study of the context, to find out its meaning.

(3) With upper classes, by studying the derivation, if possible.

(4) By getting children to give me, in their own words, the sense of the sentence in which the word occurs. By this means various synonyms for the difficult word can be found out, and its meaning thus arrived at.

(5) In the cases of some words, by finding out how the omission of the word would affect the sense of the sentence in which it is employed.

3. What are the advantages of training children to answer in sentences instead of single words?

The following are the advantages of teaching children to answer in sentences instead of single words :—

(1) The teacher is more certain of the accuracy of the child's knowledge.

(2) The teacher is also certain that the child has not misapprehended the subject.

(3) The practice of answering in complete sentences promotes accuracy and clearness of thought.

(4) It is an excellent preparation for written composition.

(5) The accuracy required to answer well in complete sentences cannot be gained without close attention to the lesson which is being given. Hence the practice of answering in complete sentences is a help to the teacher in maintaining the attention of the class.

4. If you were given charge of a class of young children, supposed to know the simple rules, but accustomed to count on their fingers, how would you proceed to get rid of this habit?

I should proceed as follows to get rid of the habit mentioned—

(1) As it is mainly for adding and subtracting that the fingers are employed, I should get the class to form with me addition and subtraction tables up to ten. In forming these, the ball frame, pieces of pencil, and other material objects, could well be employed. After the tables are formed, I should have them written on the blackboard and learned. A few minutes each day should then be given to questioning on them.

(2) See that the multiplication and division tables were thoroughly well learned. I should not regard them as being thoroughly learned unless children could answer any line in any table without having to mentally reckon up from the beginning.

(3) I should have daily practice in mental arithmetic, embracing the first four rules. I should carefully graduate the exercises, and my problems would at first only deal with things lying within the experience of the children themselves.

(4) The whole class should frequently work sums on the blackboard with me. I should require all the operations to be done mentally, only the results being written down. Each child should at first do only a small portion of the sum, so as to give every child something to do, as far as possible.

(5) To encourage the children, those who manage to do sums without employing their fingers might be put at the top of the class, have five minutes' extra play, &c.

5. For what purposes is school drill useful?

School drill is useful—

(1) As a relief to mental work, and as therefore enabling mental work to be done better after it.

(2) As a physical relief to the strain on the body caused by sitting or standing in one position. It thus tends to promote order in the class, by obviating the restlessness due to long continuance in one posture.

(3) Children like it, and it helps to make school attractive to them.

(4) Dull children, who do not excel in their lessons, often excel in drill. The drill is therefore an encouragement to these children, who are pleased and encouraged by finding that there is some part of the schoolwork for which they can get credit.

(5) Drill is not successful unless the teacher's commands are promptly and fully obeyed. Children therefore learn by it the habit of ready and exact obedience and attention.

(6) The success of the drill lesson depends also on the perfection with which the children work together. One clumsy or inattentive child may spoil an exercise which is being done. Drill therefore tends to promote *esprit de corps* in a class, making its members feel that its credit as a class depends on every member of the class doing his or her duty.

(6) Show, by giving a short sketch in each case, the different points you would bring into prominence in giving a lesson on Alfred the Great to children in the lowest class and in the highest class of a school.

In the lowest class I should give some such sketch as the following :—

Alfred the Great lived at a time when princes and kings thought little of learning. The greatest king in those times was not the one who did most for his people, but the one who most successfully led his people to battle. Alfred had, however, a mother, to please whom he learned to read. She offered a book to whichever of her sons should learn to read it first. Alfred gained the prize and his mother's praise. But he was not satisfied with

learning a little. He kept on trying to learn more. Nor did he keep his knowledge to himself. He wrote books to try and make his countrymen wiser and better. He also founded schools for them. It was because he did so much for his country in many ways that he was called the 'Great.'

I should give the substance of the above sketch to the highest class of the school, and I should add what follows :—

Alfred had a long struggle with the Danes, who appeared likely to master England, and to replunge it into barbarism. Although unsuccessful at first, he did not despair, but eventually succeeded in inducing the Danes to settle down as peaceable subjects. He then devoted his attention to securing the safety of his kingdom. He was far-sighted enough to perceive that if England has the command of the seas she is guaranteed against foreign invasion. He accordingly had a powerful navy built. He encouraged commerce, learning, and the arts. He was actuated by a high ideal of the duties entailed by the possession of a throne. His mind was continually occupied with plans for his people's happiness, and he deserves the title of 'Great' more truly than many a monarch on whom that title has been bestowed.

7. What preparation have you been taught to use before letting children attempt to work sums in weights and measures?

I have been taught to see that children understand the reasons for the processes employed in the reduction of money before they attempt to work sums in weights and measures. I have also been taught to get children to master the commonest tables of weights and measures, and to give them abundant mental practice in reducing from one denomination to another. The children were then led to see that the operations required for working sums in weights and measures involved no principles which were not employed in money sums. The only difference is the difference in the tables, which, in the working of examples in weights and measures, are employed in a way exactly similar to the way the money table is employed in working examples in money.

8. What part of the preparation for each lesson have you been accustomed to get the children of your class, or monitors chosen from them, to do for you? Why is it useful to get all possible work so done?

I have been accustomed to get the following preparation for my lessons done for me by the monitors of my class :—The monitors enter school a quarter of an hour before each session in order to get out slates, see that inkwells are filled, look over the stock of pens to see that all the points are good, and put in the children's places anything which may be wanted during the morning or afternoon, such as reading books, drawing books, etc. Whenever pens, pencils, india-rubbers, etc., are required, these are given out by the monitors immediately before the lesson when they are to be used, and collected by them at the end of the lesson. The monitors also are expected to look over the lead or slate pencils the morning or afternoon before they are to be used, and sharpen those which require it. The monitors also put up and take down the blackboard when required to do so.

They also take down maps from the walls ready for me to use, fetch models when required for drawing lessons, and go to the Head Master at 9 o'clock each morning for new supplies of anything necessary.

It is useful to get all necessary work done by monitors, because it enables the teacher to give practically all his time to teaching. It also leaves him free to keep a continual watch over the conduct of his class, and prevents him going in among his children more than is necessary. It is also useful because I have been accustomed to make the position of monitor a reward for good work and good behaviour. I have found the system a great help towards the maintenance of discipline. To the boys themselves it is useful, as it teaches them to be handy and obliging, and accustoms them to the idea of responsibility.

9. What variety of occupations have you found suitable for children between five and six years old?

I have found the following occupations suitable for children between five and six years old :—

1. Bead and straw threading.
2. Stick laying.
3. Mat weaving.
4. Paper folding.
5. Elementary clay modelling.
6. Embroidery.

10. Give the explanations you would think necessary for a class of children for whom the following passage in their reading book was suitable :—

'These glaciers are the principal characteristics of the scenery in Spitzbergen; the bottom of every valley in every part of the island is occupied, and generally completely filled, by them, enabling one in some measure to realize the appearance of England during her glacial period, when Snowdon was still being slowly lifted towards the clouds, and every valley in Wales was brimful of ice.'

1. *Glaciers.* Rivers of ice, occupying valleys in mountains extending above the snow line. They are continually moving slowly down the valley.

2. *Principal*, chief.

3. *Characteristics*, most striking features, *i.e.*, those features which give the peculiar character to the scenery; thus the chief characteristics of Holland are the flatness of the country and the canals which intersect it.

4. *Scenery.* The whole combination of *natural* appearances, comprising rivers, lakes, mountains, trees, etc., etc. What are the chief characteristics of the scenery in your neighbourhood?

5. *Spitzbergen*, an island in the Arctic Ocean to the north of Europe.

6. *Realize*, to form a mental picture of anything which is not actually before us. We can thus make it *real* to ourselves so that it no longer remains a thing told us, or a thing of which we have only seen the picture. Thus we may try to realize the appearance of a person who has been described to us.

7. *Appearance*, the look or outward aspect of England.

8. *Glacial period*, a period in the world's history when our country had an Arctic climate, when there were glaciers in our mountain valleys, and icebergs on our coasts.

9. *Snowdon was still being slowly lifted.* Many parts of the earth's surface are gradually being raised, while many other parts are gradually being depressed. Thus many parts of our coasts are at the present day slowly sinking.

10. *Brimful*, full to the brim or edge.

## EUCLID.—MEN.

Friday, December 21st, 2 to 4.

1. Define *line, plane, superficies, right angle, circle, theorem.* What is the difference between a *postulate* and an *axiom?*

*First part.*—All book work except *theorem.*

A *theorem* is a proposition containing something to be proved. Thus the following propositions in Book I. are theorems—5, 35, and 47.

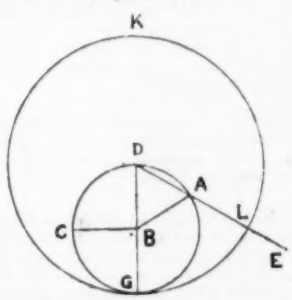
In the postulates, we demand, as a basis of reasoning, that the geometrical operations they refer to shall be considered to be perfectly done. This is to prevent our demonstrations being impugned on account of imperfect drawing. They also demand that no proof shall be required of the operations stated being effected.

An *axiom* is a truth of so self-evident a character that it cannot be made clearer by any attempted demonstration of it.

2. From a given point, draw a straight line equal to a given straight line.

If in the figure the diameter of the larger circle is double that of the smaller one, show where the given point and the vertex of the constructed triangle will be situated.

*First part.*—Book work, Euc. I. 2.




*Second part.*—See diagram.

If the diameter of the larger circle is double that of the smaller, its radius equals the diameter of the smaller. Then, as DG is the radius of the larger circle, the point D is situated in the circumference of the smaller circle, and DB is a radius of the smaller circle. But as DB = BA, BA is also a radius

of the smaller circle, and the point A is situated in the circumference of the smaller circle. In other words, the distance BA equals the given straight line BC.

3. Draw a straight line perpendicular to a given straight line of unlimited length from a given point without it.

When is it necessary for the given straight line to be of unlimited length?

What step is taken in the construction in order to make it certain that the circle drawn will intersect the given straight line?

(1) Book work, Euc. I. 12.

The given straight line must be of unlimited length because we may take *any* point on the other side. Now, as we have to draw a circle whose radius shall be the distance from the given point to the point we take, the given straight line may be too short to be intersected on both sides by this circle. We must, therefore, reserve to ourselves the power of producing the line, if necessary, either way.

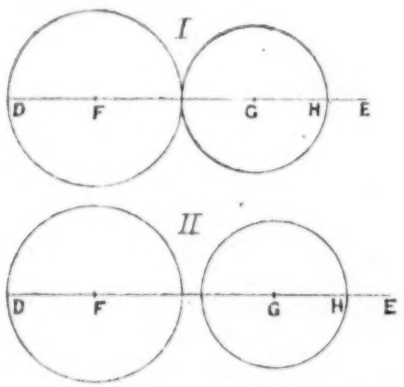
The step we take in the construction in order to make it certain that the circle drawn will intersect the given straight line is to state as a proviso that this line may be produced to any length both ways.

4. Make a triangle of which the sides shall be equal to three given straight lines, but any two whatever of these must be greater than the third.

In the construction two circles are drawn. Prove that, under the conditions given, these circles will always intersect each other.

How many different triangles can be made, each of which has the three given sides?

*First part.*—Book work.




*Second part.*—In the two diagrams, DF, FG, GH respectively equal the lengths of three given straight lines. In diagram I. the circles touch one another, and it is evident that FG = the sum of the radii of the two circles, that is, it exactly *equals* the sum of the other two sides FD and GH.

In diagram II., where the circles do not even touch, FG is *less* than the sum of the other two sides DF and GH.

It is evident, then, that as the circles only *touch* when one straight line is equal to the sum of the other two, and recede farther from each other as FG increases in length, that FG must be made shorter than it is in diagram I. to permit of the circles intersecting one another. In other words, the circles intersect because the sum of any two of the straight lines is greater than the third.

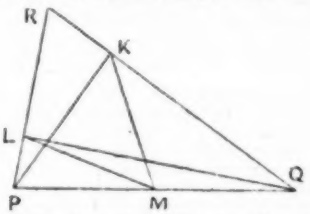
*Third part.*—Only one triangle can be made having the three given sides. The only effect of varying the sides in position is to cause the angles to take different positions, but not to alter them. The angle which subtends a given side will always be of the same value.

5. If a side of any triangle be produced, the exterior angle is equal to the two interior and opposite angles, and the three interior angles of every triangle are together equal to two right angles.

From the angles P and Q of a triangle PQR, perpendiculars are drawn to the opposite sides, meeting them produced, if necessary, in K and L. Prove that the straight lines which join K and L to the middle point of the side PQ are equal to each other.

*First Part.* Book work, Euc. I. 32.

*Second Part.* Let M be the middle point of PQ. PKQ is a right angled triangle. MK = MQ or MP. For if MK do not = MQ or MP, it is either less than each of these equals, or greater than each of them. If MK be less than MQ, then the angle MQK is less than MKQ (I. 18). Similarly if MK




is less than MP, the angle MPK is less then MKP. Therefore, the two angles MPK and MQK together are less than PKQ. But since the three angles PKQ, KQP, and QPK, are together equal to two right angles (I. 32) and the angle PKQ is a right angle (constr.), therefore the two angles KPQ and PQK together = a right angle, that is, they together = PKQ. Therefore, the two angles KPQ and PQK are both less and equal to PKQ, which is absurd. Then MK is not less than MP or MQ.

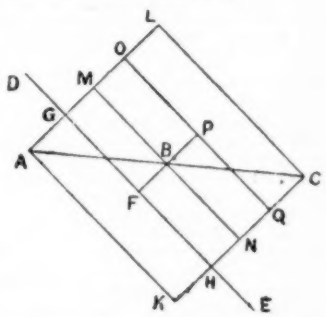
Similarly, by supposing MK greater than MQ or MP, we can show that the angles PQK and KPQ are together greater than PKQ, which is another absurdity. Therefore, MK is not greater than MP or MQ; and we have shown it not to be less than either of these. Therefore it equals either of them.

In like manner we can show that ML = MP or MQ. Therefore MK = ML (Ax. 1).

6. The opposite sides and angles of a parallelogram are equal to one another.

A, B, and C are three points in a straight line, so that AB is equal to BC, show that the difference of the perpendiculars from A and C on any straight line which passes between A and C is double the perpendicular from B on the same straight line.

*First Part.* Book work, Euc. I. 34.



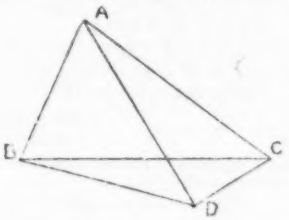

*Second Part.* Let DE be the straight line which passes between A and C, and AG, BF, CH respectively the perpendiculars on it from A, B, and C.

Draw AK parallel to GH to meet CH produced in K. Also draw CL parallel to GH to meet AG produced in L. Through B draw MBN parallel to GH, meeting AL in M and CK in N. Produce FB to P, making BP = BF. Then all the figures GAKH, GHNM, NMOQ, and QOLC are parallelograms. In the triangles ABM and BNC, since one side in each, AB and BC, is equal and the angle AMB = the angle BNC (I. 29) and the angle MBA = angle CBN (I. 15) then (I. 26) the two triangles are equal. Then the side NC = the side MA. And since NQ = BP (I. 34) and MG = BF (I. 34) and BP = BF (constr.), then NQ = MG. And since the whole MA = the whole NC, the remainder QC = AG, which is the perpendicular from A on the given line DE. And CH is the perpendicular from C on the given line. Then, since CQ, a part of it = AG, the remainder QH = the difference between the perpendiculars from A and C on the given line. But QH = the sum of NQ and NH, which are equal, since they each equal BP or BF (I. 34), which were made equal. Therefore QH is the double of BF, which is the perpendicular from B on the given line DE.

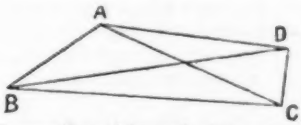
7. If the square described on one of the sides of a triangle be equal to the squares described on the other two sides of it, the angle contained by these two sides is a right angle.

If the squares on one side of a triangle be less than the squares on the other two sides, the angle contained by these two sides is an acute angle; if greater, an obtuse angle.

*First Part.* Book work, Euc. I. 48.




*Second Part.* (*a*) Let the square on BC be less than the squares on AB and AC. Then BAC must be an acute angle. For if it is not an acute angle, it is either a right or an obtuse angle. If it be a right angle, the sq. on BC = the sum of the sqs. on AB and AC. But the sq. on BC does not = the sum of these two sqs. Then BAC is not a right angle. Suppose it to be an obtuse angle. At A make the right angle BAD. Make AD = AC, and join CD and BD. Then by I. 47 the sq. on BD = the sum of the sqs. on AB and AD, that is, the sum of the sqs. on AB and AC, since AD = AC. But since the sq. on BC is less than the sum of these sqs., BC is less than BD. Therefore the angle BDC is less than the angle BCD (I. 18). But the angle ACD = angle ADC (I. 5). And the angle ACD is greater than angle BCD. Then the angle ADC is greater than angle BCD. Much more then is BDC greater than BCD. Therefore BDC is both less and greater than BCD, which is absurd. Then BAC is not obtuse. And it has been proved not to be a right angle. Therefore it is an acute angle.

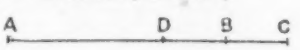



(*b*) BAC cannot be a right angle, because sq. on BC would equal sum of sqs. on BA and BC. Then, if it is not obtuse, it must be acute. Suppose it to be acute. At A make right angle BAD. Make AD = AC and join CD. Then sq. on BD = sum of sqs. on AB and AD, that is, on AB and AC. Then, as was shown in (*a*), BD is less than BC. Therefore angle BCD is less than angle BDC (I. 18). But angles ADC and ACD are equal (I. 5). Angle ADC is greater than BDC. Therefore ACD is greater than BDC. Much more then is BCD greater than BDC. That is, BCD is both less and greater than BDC, which is absurd. Then the angle BAC is not acute. And it has been shown not to be a right angle. Therefore BAC is an obtuse angle.

8. If a straight line be divided into any two parts, the square on the whole line is equal to the squares on the two parts, together with twice the rectangle contained on the parts.

Show that the squares on the sum of two straight lines, together with the square on their difference, is double the squares on the two straight lines.

*First Part.* Book work, Euc. II. 4.




*Second Part.* Let AB and BC be the two given straight lines. AC is their sum. Make DB = BC. Then AD is the difference of the two straight lines.

By Euc. II. 4.

$AC^2 = AB^2 + BC^2 + 2\,AB.BC.$

To each of these equals add $AD^2$.

Then $AC^2 + AD^2 = AB^2 + BC^2 + 2\,AB.BC + AD^2$.

But AB = AD + DB = AD + BC.

Then $AC^2 + AD^2 = AB^2 + BC^2 + 2\,BC\,(AD + BC) + AD^2$

$= AB^2 + BC^2 + 2\,BC.AD + 2\,BC^2 + AD^2$

$= 2\,BC^2 + AB^2 + (BC^2 + 2\,BC.AD + AD^2)$.

But by Euc. II. 4, $BC^2 + 2\,BC.AD + AD^2$ = the square on the line made up of AD and BC.

But AB is the line made up of AD and BC, since DB = BC.

Therefore $BC^2 + 2\,BC.AD + AD^2 = AB^2$.

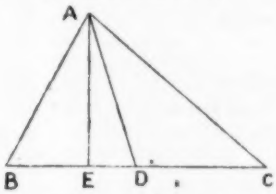
Then $AC^2 + AD^2 = 2\,BC^2 + AB^2 + AB^2 = 2\,BC^2 + 2\,AB^2$.

That is, the square on the sum of two straight lines, together with the square on their difference, is double the squares on the two straight lines.

9. In every triangle, the square on the side subtending an acute angle is less than the squares on the sides containing that angle, by twice the rectangle contained by either of these sides, and the straight line intercepted between the perpendicular let fall on it from the opposite angle and the acute angle.

ABC is any triangle, and D is the middle point of BC. Prove that the sum of the squares on the sides AB and AC is double the sum of the squares on the straight lines AD and DC.

*First Part.* Book work, Euc. II. 13.




*Second Part.* If the angles ADB and ADC be right angles sq. on AB = sq. on BD + sq. on AD (I. 47).

And sq. on AC = sq. on DC + sq. on AD.

Then sq. on AB + sq. on AC = 2 sq. AD + sq. on BD + sq. on DC.

But BD = DC. Then sq. on BD = sq. on DC.

Then sq. on AB + sq. on AC = 2 sq. on AD + 2 sq. on DC.

But if the angles BDA, ADC be not each right angles, one of them is acute, and the other obtuse. Suppose ADB to be an acute angle. Then ADC is an obtuse angle. From A drop perpendicular AE on BC.

Then sq. on AB = sq. on AD + sq. on BD — twice rect. BD.DE (II. 13).

And sq. on AC = sq. on AD + sq. on DC + twice rect. DC.DE.

But DC = BD. Then rect. DC.DE = rect. BD.DE.

Therefore sq. on AB added to sq. on AC = 2 sq. on AD + sq. on BD + sq. on DC.

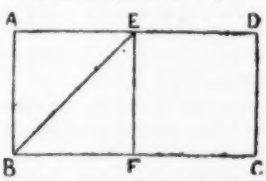
But sq. on BD = sq. on DC, since BD = DC.

Then sq. on AB + sq. on AC = 2 sq. on AD + 2 sq. on DC.

10. Describe a square that shall be equal to a given rectilineal figure.

A rectangle has its long sides double the length of its short sides; describe a square equal in area, without using a circle in the construction.

*First Part.* Book work, Euc. II. 14.




*Second Part.* Let ABCD be a rectangle having its long side AD double its short side AB. Bisect AD in E. From E draw EF parallel to AB or CD. Then by Euc. I. 29 the adjacent angles at E and F are each right angles, and since AE is the half of AD, and AD is the double of AB, AE equals AB and ABFE is a square. Similarly, EDCF is a square described on ED, which = AB. Then the whole rectangle is double either of the equal squares ABFE and FEDC.

Join EB. By I. 47 the square on EB is equal to the sum of the squares on EA and AB. But the squares on EA and AB each equal either of the squares ABFE and EFCD. Therefore their sum equals the whole rectangle. Therefore the square on EB equals the whole rectangle ABCD.

## ALGEBRA AND MENSURATION.—MEN.

Friday, December 21st, 10 to 12.

1. Simplify $(a+2)^3 - 4(a+1)^3 + 6a^3 - 4(a-1)^3 + (a-2)^3$.

$(a+2)^3 - 4(a+1)^3 + 6a^3 - 4(a-1)^3 + (a-2)^3$

$= (a^3 + 6a^2 + 12a + 8) - 4(a^3 + 3a^2 + 3a + 1) + 6a^3 - 4(a^3 - 3a^2 + 3a - 1) + (a^3 - 6a^2 + 12a - 8)$

$= a^3 + 6a^2 + 12a + 8 - 4a^3 - 12a^2 - 12a - 4 + 6a^3 - 4a^3 + 12a^2 - 12a + 4 + a^3 - 6a^2 + 12a - 8$

$= 0.$

2. Prove that if $c$ be any positive integer, $a$ and $b$ having *any* values whatever, then

$$(a + b)c = ac + bc,$$

and hence deduce that, if $d$ be also *any* positive integer,

$$(a + b) \times \frac{c}{d} = a \times \frac{c}{d} + b \times \frac{c}{d}$$

$(a + b)c = (a + b) + (a + b) + (a + b) + (a + b)$, etc., up to $c$ times

$= a + b + a + b + a + b + a + b$, etc., up to $c$ times.

In this expression $a$ appears $c$ times and $b$ appears $c$ times.

Then $(a + b)c = ac + bc$.

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$(a + b)\frac{c}{d} = (a + b) + (a + b)$, etc., up to $c$ times, and the $d$th part of the result taken

$$= \frac{ac + bc}{d}$$

$$= \frac{ac}{d} + \frac{bc}{d}$$

$$= a \times \frac{c}{d} + b \times \frac{c}{d}$$

3. Find the factors of $xyz(x^3 + y^3 + z^3) - y^3z^3 - z^3x^3 - x^3y^3$.

$xyz(x^3 + y^3 + z^3) - y^3z^3 - z^3x^3 - x^3y^3$

$= x^4yz + xy^4z + xyz^4 - y^3z^3 - z^3x^3 - x^3y^3$.

Rearranging:

$= x^4yz - x^3y^3 + xyz^4 - y^3z^3 - z^3x^3 + xy^4z$.

Bracket these in pairs, putting common factors outside of brackets:

$= x^3y(xz - y^2) + yz^3(xz - y^2) - xz(x^2z^2 - y^4)$

$= x^3y(xz - y^2) + yz^3(xz - y^2) - xz(xz + y^2)(xz - y^2)$

$= (xz - y^2)\{x^3y + yz^3 - xz(xz + y^2)\}$

$= (xz - y^2)(x^3y + yz^3 - x^2z^2 - xy^2z)$.

Rearranging terms in 2nd bracket:

$= (xz - y^2)\{(x^3y - x^2z^2) - (xy^2z - yz^3)\}$.

Put common factors outside each pair of the small brackets within the larger brackets:

$= (xz - y^2)\{x^2(xy - z^2) - yz(xy - z^2)\}$

$= (xz - y^2)(x^2 - yz)(xy - z^2)$.

4. Prove that $a \times b = b \times a$ where $a$ and $b$ are *any* positive integers.

$1 \times a = 1 + 1 + 1 + 1 + 1$ (up to $a$ times) $= a$.

But $a$ = once $a$ or $a \times 1$.

$\therefore a \times 1 = 1 \times a$, or $a$ taken once $= 1$ taken $a$ times.

Then $a$ taken $b$ times is $b$ times as great as 1 taken $a$ times. But 1 taken $a$ times $= a$ taken once.

Then $a$ taken $b$ times, or $a \times b = b$ times $a$ taken once

$= b$ times $a$.

Therefore $a \times b = b \times a$.

5. Find the Lowest Common Multiple of

$8x^3 + 27$, $16x^4 + 36x^2 + 81$, and $6x^2 - 5x - 6$.

$8x^3 + 27 = (2x)^3 + (3)^3$

$= (2x + 3)(4x^2 - 6x + 9)$.

$16x^4 + 36x^2 + 81 = (16x^4 + 72x^2 + 81) - 36x^2$

$= (4x^2 + 9)^2 - (6x)^2$

$= (4x^2 + 6x + 9)(4x^2 - 6x + 9)$.

$6x^2 - 5x - 6 = (3x + 2)(2x - 3)$.

$\therefore$ L.C.M. of the three quantities

$= (2x + 3)(4x^2 - 6x + 9)(4x^2 + 6x + 9)(3x + 2)(2x - 3)$

$= \{(2x + 3)(4x^2 - 6x + 9)\} \times \{(2x - 3)(4x^2 + 6x + 9)\} \times (3x + 2)$

$= (8x^3 + 27)(8x^3 - 27)(3x + 2)$

$= (3x + 2)(64x^6 - 729)$.

6. Solve the equations

(1) $3(x + 3)^2 + 5(x + 5)^2 = 8(x + 8)^2$

(2) $\begin{cases} ax + by = 2ab. \\ bx - ay = b^2 - a^2. \end{cases}$

(3) $\frac{3x - 4}{x + 1} - \frac{x - 1}{3x + 4} + \frac{1}{2} = 0.$

(1) $3(x^2 + 6x + 9) + 5(x^2 + 10x + 25) = 8(x^2 + 16x + 64)$.

$\therefore 3x^2 + 18x + 27 + 5x^2 + 50x + 125 = 8x^2 + 128x + 512$.

$\therefore 3x^2 + 18x + 5x^2 + 50x - 8x^2 - 128x = -27 - 125 + 512$.

$\therefore -60x = 360$.

$\therefore x = -6$.

(2) Multiply every term of the first equation by $b$, and every term of the second equation by $a$.

$\therefore abx + b^2y = 2ab^2$

And $abx - a^2y = ab^2 - a^3$.

Subtract: $b^2y + a^2y = ab^2 + a^3$.

$\therefore y(b^2 + a^2) = a(b^2 + a^2)$.

$\therefore y = a$.

Substitute the value $y = a$ in the equation

$ax + by = 2ab$,

$\therefore ax + ab = 2ab$.

Divide all terms by $a$, then

$x + b = 2b$,

$\therefore x = 2b - b$,

$\therefore x = b$.

(3) $\frac{3x - 4}{x + 1} - \frac{x - 1}{3x + 4} + \frac{1}{2} = 0.$

Multiply all the terms by the L.C.M. of the denominators, that is, by

$2(x + 1)(3x + 4)$,

$\therefore 2(3x - 4)(3x + 4) - 2(x + 1)(x - 1) + (x + 1)(3x + 4) = 0$.

$\therefore 2(9x^2 - 16) - 2(x^2 - 1) + (3x^2 + 7x + 4) = 0$.

$\therefore 18x^2 - 32 - 2x^2 + 2 + 3x^2 + 7x + 4 = 0$.

$\therefore 19x^2 + 7x - 26 = 0$.

Resolve into factors:

$\therefore (19x + 26)(x - 1) = 0$.

$\therefore 19x + 26 = 0$

Then $19x = -26$ and $x = -1\frac{7}{19}$,

And $x - 1 = 0$.

Then $x = 1$.

7. The sum of two numbers multiplied by the greater is 352, and their difference multiplied by the less is 60; find them.

Let $x$ = greater number.

$y$ = less number.

Then $x(x + y) = 352$. (A)

And $y(x - y) = 60$. (B).

Multiply (A) by 15. Then $15x(x + y) = 5280$.

Multiply (B) by 88. Then $88y(x - y) = 5280$.

$\therefore 15x(x + y) = 88y(x - y)$.

$\therefore 15x^2 + 15xy = 88xy - 88y^2$.

$\therefore 15x^2 - 73xy = -88y^2$.

Divide every term by 15:

$$\therefore x^2 - \frac{73}{15}xy = -\frac{88y^2}{15}.$$

Add the square of $\frac{73}{30}y$ to each side:

$$\therefore x^2 - \frac{73}{15}xy + \left(\frac{73y}{30}\right)^2 = \left(\frac{73y}{30}\right)^2 - \frac{88y^2}{15}$$

$$= \frac{5329y^2}{900} - \frac{88y^2}{15}$$

$$= \frac{5329y^2 - 5280y^2}{900}$$

$$= \frac{49y^2}{900}.$$

Extract square root of each side:

$$\therefore x - \frac{73y}{30} = \pm\frac{7y}{30}.$$

$$\therefore x = \frac{73y}{30} \pm \frac{7y}{30}; \quad \therefore x = 2\tfrac{3}{5}y \text{ and } 2\tfrac{1}{5}y.$$

Substitute the first of these values in equation (A) :

$$\text{Then } 2\tfrac{2}{3}y(2\tfrac{2}{3}y + y) = 352.$$

$$\therefore 2\tfrac{2}{3}y \times 3\tfrac{2}{3}y = 352\ ;\ \therefore \frac{88y^2}{9} = 352\ ;$$

$$\therefore 88y^2 = 3168\ ;\ \therefore y^2 = 36\ ;\ \therefore y = \pm 6.$$

If $y = \pm 6$, then $x = \pm 6 \times 2\frac{2}{3} = \pm 16$.

Now substitute the value $x = 2\frac{2}{3}y$ in equation (A).

$$2\tfrac{2}{3}y\,(2\tfrac{2}{3}y + y) = 352.$$

$$\therefore 2\tfrac{2}{3}y \times 3\tfrac{2}{3}y = 352.$$

$$\therefore \tfrac{176}{25}y^2 = 352\ ;\ \therefore 176y^2 = 8800.$$

$$\therefore y^2 = 50\ ;\ \therefore y = \pm 2\sqrt{5}.$$

$$\text{If } y = \pm 2\sqrt{5}, \text{ then } x = \pm 2\sqrt{5} \times \tfrac{11}{5} = \frac{\pm 2\sqrt{5} \times 11}{5}.$$

$$= \frac{\pm 22}{\sqrt{5}}.$$

These surd values do not satisfy the equation.

$$\therefore x = \pm 16\ ;\ y = \pm 6.$$

8. On a certain road the telegraph posts are at equal distances, and the number per mile is such that if there were one less in each mile, the interval between the posts would be increased by $3\frac{7}{11}$ yds. Find the number of posts per mile.

Let $x$ = the number of posts per mile.

Then $\frac{1760}{x}$ = distance between posts in yards.

$$\text{Then } \frac{1760}{x-1} = \frac{1760}{x} + 3\tfrac{7}{11}.$$

Multiply all terms by $11x(x-1)$.

Then $36960x = 36960(x-1) + 80x(x-1)$.

$\therefore 36960x = 36960x - 36960 + 80x^2 - 80x$.

$\therefore -80x^2 + 36960x - 36960x + 80x = -36960$.

$\therefore -80x^2 + 80x = -36960$.

Divide all terms by $-80$.

$\therefore x^2 - x = 462$.

$\therefore x^2 - x - 462 = 0$. $\therefore (x-22)(x+21) = 0$.

$\therefore x - 22 = 0$.

$\therefore x = 22$ posts.

The equation $x + 21 = 0$ would give a value $-21$, which is inadmissible.

9. (1) Find the value of $k$ in order that $x^6 + 2x^5 + 3x^4 + 4x^3 + 3x^2 + 2x + k$ may be a perfect square.

Extract the square root of the quantity.

$$x^6 + 2x^5 + 3x^4 + 4x^3 + 3x^2 + 2x + k \,|\, x^3 + x^2 + x + 1$$

$x^6$

$2x^3 + x^2 \;|\; + 2x^5 + 3x^4$

$\quad 2x^5 + x^4$

$2x^3 + 2x^2 + x \;|\; + 2x^4 + 4x^3 + 3x^2$

$\quad + 2x^4 + 2x^3 + x^2$

$2x^3 + 2x^2 + 2x + 1 \;|\; 2x^3 + 2x^2 + 2x + k$

$\quad 2x^3 + 2x^2 + 2x + 1$

$\therefore k$ must $= 1$.

(2) Find the cube root of $x^6 - 3x^5 + 6x^4 - 7x^3 + 6x^2 - 3x + 1$.

$3x^2 - x$ | $3x^4$ | $x^6 - 3x^5 + 6x^4 - 7x^3 + 6x^2 - 3x + 1 \,|\, x^2 - x + 1$

$-2x$ | $-x(3x^2 - x)$ | $x^6$

$3x^2 - 3x$ | $3x^4 - 3x^3 + x^2$ | $\quad -3x^5 + 6x^4 - 7x^3$

$\quad -3x^5 + 3x^4 - x^3$

$3x^2 - 3x$ | $3x^4 - 6x^3 + 3x^2$ | $3x^4 - 6x^3 + 6x^2 - 3x + 1$

$+1$ | $3x^2 - 3x + 1$ | $3x^4 - 6x^3 + 6x^2 - 3x + 1$

$3x^2 - 3x + 1$ | $3x^4 - 6x^3 + 6x^2 - 3x + 1$

Ans. $x^2 - x + 1$.

## MENSURATION.

10. A field in the shape of a semicircle is surrounded by a wall 252 yards long. Find the area, assuming $\pi = \frac{22}{7}$.

The wall extends along the curve of the semicircle and the diameter. These are in the ratio of $1 : \frac{11}{7}$. We have therefore to divide 252 yards in the ratio of $1 : \frac{11}{7}$ to find out how much of the wall extends along the straight diameter, and how much along the curve of the semicircle.

$$1 + \tfrac{11}{7} = \tfrac{18}{7}.$$

$252 \text{ yds.} \times \frac{1}{\frac{18}{7}} = 252 \text{ yds.} \times \frac{7}{18} = 98 \text{ yds.}$, the length of the diameter.

$\therefore r$, the radius, $= 49$ yds.

Area of circle $= \pi r^2$.

$$\therefore \text{Area of semicircle} = \frac{\pi r^2}{2}$$

$$= \frac{\frac{22}{7} \times (49)^2}{2} \text{ sq. yds.}$$

$$= \frac{22 \times 2401}{14} \text{ sq. yds.}$$

$$= 3773 \text{ sq. yds.}$$

11. A rectangular sheet of paper is covered with penny postage stamps. If the sides were each one inch less, the length of the paper would be twice its breadth ; but if the sides were each ten inches more, the length would be $1\frac{1}{2}$ times the breadth. Find the cost of the stamps used. (Dimensions of stamp $\frac{23}{24}$ ins. long and $\frac{1}{4}$ ins. wide.)

Let $x$ = length of paper in inches.

$y$ = breadth ,, ,,

$xy$ = area ,, sq. inches.

$x - 1 = 2(y - 1)$ (A)

$x + 10 = 1\frac{1}{2}(y + 10)$ (B)

By (B) $x + 10 = 1\frac{1}{2}y + 15$.

By (A) $x - 1 = 2y - 2$.

Subtract: $\therefore 11 = -\frac{1}{2}y + 17$.

$\therefore \frac{1}{2}y = 17 - 11$.

$\therefore \frac{1}{2}y = 6$.

$\therefore y = 12$ ins.

Substitute this value in (A) :

$\therefore x - 1 = 2(12 - 1)$.

$\therefore x - 1 = 22$.

$\therefore x = 23$ ins.

Area of rectangle $= 23$ in. $\times 12$ in. $= 276$ sq. in.

Area of 1 stamp $= \frac{23}{24}$ in. $\times \frac{1}{4}$ in.

$$= \frac{23 \times 1}{24 \times 5} \text{ sq. ins.} = \frac{23}{30} \text{ sq. ins.}$$

Number of stamps used $= 276 \div \frac{23}{30}$.

$= 276 \times \frac{30}{23} = 360$.

Value of stamps $= 360d. = £1\ 10s.$

## LATIN.—MEN AND WOMEN.

Friday, December 21st, 4 to 6.

1. Translate into English :—

Aedui, quum se suaque ab iis defendere non possent, legatos ad Caesarem mittunt *regatum* auxilium ; Ita se omni tempore de

Populo Romano *meritos esse* ut paene in conspectu exercitus nostri agri vastari, liberi *eorum* in servitutem abduci, oppida expugnari non debuerint. Quibus rebus adductus Caesar non *exspectandum* sibi statuit dum omnibus fortunis sociorum consumptis in Santonos Helvetii *pervenirent*.

The Ædui, since they could not defend themselves and their possessions from these people, send ambassadors to Cæsar to ask for help. They remind him that the services they had always rendered the Roman people were of such a character that their fields ought not to be laid waste almost in the sight of our army, their children led into slavery, and their towns taken by storm. Moved by these statements, Cæsar determined that they should not wait for him until, after all the resources of the allies had been exhausted, the Helvetii penetrated as far as the Santoni.

2. Translate into English :—

Quamobrem *placuit* ei ut ad Ariovistum legatos mitteret, qui ab eo postularent, uti aliquem locum medium *utriusque* colloquio deligeret : velle sese de republica et summis utriusque rebus cum eo agere. Ei legationi Ariovistus respondit: Si quid *ipsi a* Caesare opus esset, sese ad eum *venturum fuisse :* si quid ille *se* velit, illum ad se venire oportere. Praeterea se neque sine exercitu in eas partes Galliæ venire audere quas Caesar possideret, neque exercitum sine magno commeatu atque emolimento in unum locum contrahere posse.

And for this reason it pleased him to send ambassadors to Ariovistus to ask of him to choose some place for a conference midway between the two of them. (The ambassadors were commanded to say) that Cæsar wished to confer with him on public affairs, and on matters deeply affecting both of them. Ariovistus made answer to the embassy as follows : (He said) that if he himself needed anything from Cæsar, he would have gone to him, and that if Cæsar wanted him for any purpose, he should have come to him. Moreover, he neither dared to proceed without an army into those parts of Gaul which Cæsar held, nor could an army be brought together into one place without great trouble and great store of provisions.

3. Translate into English :—

Ita nostri acriter in hostes signo dato impetum fecerunt, *itaque* hostes repente celeriterque procurrerunt, ut spatium *pila* in hostes coniciendi non daretur. Rejectis pilis *cominus* gladiis pugnatum est. At Germani celeriter ex consuetudine sua phalange facta impetus gladiorum exceperunt. Reperti sunt complures nostri milites qui in phalangas *insilirent* et scuta manibus revellerent et desuper vulnerarent. Quum hostium acies a sinistro cornu pulsa atque in fugam conversa esset, a dextro cornu vehementer multitudine suorum nostram aciem *premebant*.

So our men, the signal of battle having been given, made a fierce attack on the enemy, and the enemy made a sudden and rapid rush forward in such a manner as to leave our men no room to hurl their darts. A hand to hand fight with swords followed, no use being made of the darts. But the Germans, quickly forming square, as was their wont, received thus the attack of the Roman swordsmen. Several of our men were found bold enough to leap into the squares, snatch the shields from the hands of the enemy, and to inflict wounds by downward thrusts on them. Although the line of the enemy was driven back and put to flight on the left wing, yet on the right wing they kept up a harassing attack on our line with a strong force.

1. *Rogatum*, supine of the 1st conj. reg. verb *rogare*, used with *mittunt* to express purpose.

*Meritos esse*, perfect infin., masc., plur., of the deponent 2nd conj. reg. verb *mereri*, used in *oratio obliqua*, and agreeing with *se* in numb. and gend.

*Eorum*, genitive plural of *is*.

*Exspectandum*, gerund of the 1st conj. reg. verb *exspecto*, forming with *esse* understood an acc. and infin. depending on *statuit*. The gerund here expresses an obligation.

*Pervenirent*, imperf. subj., 3rd plur. of the irreg. 4th conj. *pervenio*, agreeing in numb. and gend. with its subj., *Helvetii*.

2. *Placuit*, pres. perf. indic., 3rd sing. of the reg. 2nd conj. verb *placeo*. Used impersonally, and governing *ei* in the dative.

*Utriusque*, genitive sing. of pronoun *uterque*. The genitive depends on *medium*.

*Ipsi*, dat. sing. of *ipse*. Dative depends on *opus esset*, and implies with this form of expression the person who feels the need.

*A*, preposition governing *Caesare* in the ablative. *A* with an abl., used with *opus esset*, denotes the person who can supply the need.

*Venturum fuisse*, future perf. inf., masc., sing. of irreg. 4th conj. verb *venio*. Used with *sese* in *oratio obliqua*.

*Se*, accusative sing. of the pronoun *sibi*, etc., governed by *velit*. Refers to Ariovistus.

3. *Itaque*, formed of the adverb of manner *ita*, and the enclitic *que* (and) ; modifies *procurrerunt*.

*Pila*, acc. plur. of *pilum*, governed by the gerund *coniciendi*.

*Cominus*, adverb of manner (formed of *con* + *manus*, and = 'hand to hand'), modifying *pugnatum est*.

*Insilirent*, imperf. subj., 3rd plur. of the irreg. 4th conj. verb *insilio*, agreeing in number and person with *qui*. *Qui* with a subjunctive forms a qualitative adjective sentence. The idea is that the men were of *such* boldness *that* they leaped, etc.

*Premebant*, imperf. indic., 3rd plur. of the irreg. 3rd conj. verb *premo*. The imperfect here denotes a continued action.

5. (*a*) *Dies* may be either masculine or feminine in the singular. In the plural it is only masculine.

*Dies*, m. s., equals a day generally, as *obire diem supremum*, to meet one's last day ; to die.

*Dies*, f. s., equals a set day or interval of time, as *diem statuere ante quam*, to appoint a term up to which time.

(*b*) *A. d. V. Kal. Ap.* Write this out at full length, explain, and state the meaning in modern phrase.

*A. d. V. Kal. Ap.* = *ante diem quintum Kalendas Apriles.*

This mode of expressing dates is used almost exclusively by Cicero and Livy. The regular form to which it corresponds is *die quinto ante Kalendas Apriles, i.e.*, the fifth day before the Kalends of April. The Kalends of April was April 1st. As the Romans included both the day from which they reckoned backward and the day to which they reckoned, the fifth day before the Kalends of April was not March 27th, but March 28th.

(*c*) Divico ita cum Caesare egit : Si pacem, inquit, populus Romanus cum Helvetiis faciet, in eam partem ibunt atque ibi erunt Helvetii ubi constitueris : reminiscere autem pristinæ virtutis Helvetiorum.

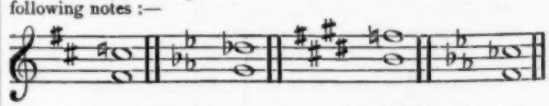
(*d*) Vesontio was a town of the part of Roman Gaul called Maxima Sequanorum. The town was on the Dubis, a tributary of the Rhodanus. Vesontio is now called Besançon ; the Dubis in modern French is the Doubs, the Rhodanus is the Rhone, whilst Maxima Sequanorum comprises the French departments of the Jura, Doubs and Haute Saône, and the cantons of Geneva and Neuchâtel in Switzerland.

## MUSIC.—Men and Women.

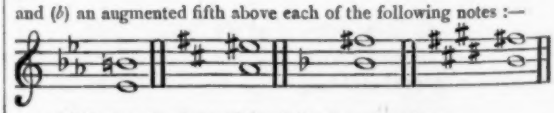
Thursday, December 20, 2.30 to 3.15.

### Staff Notation.

1. Write (*a*) an imperfect or diminished fifth above each of the following notes :—

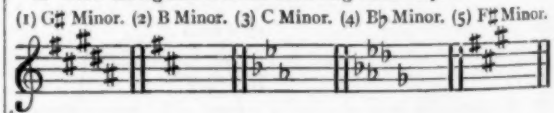


and (*b*) an augmented fifth above each of the following notes :—

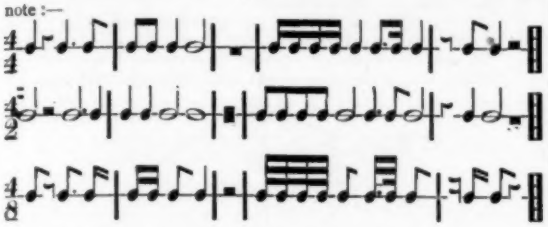


2. Write the signatures of the following minor keys :—

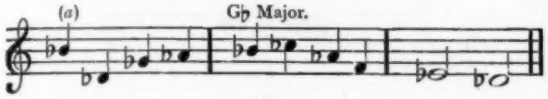
(1) G♯ Minor. (2) B Minor. (3) C Minor. (4) B♭ Minor. (5) F♯ Minor.



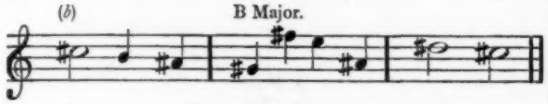
3. Re-write the following in $\frac{4}{2}$ time, doubling the value of every

note and rest, and again in $\frac{4}{8}$ time, halving the value of every note :—

4. State the key of each of the following passages :—

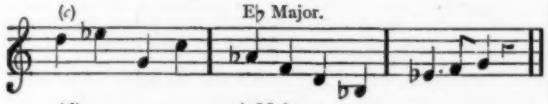
(*a*) G♭ Major.



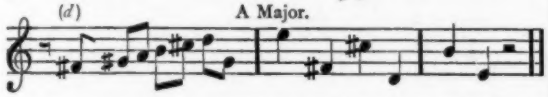
(*b*) B Major.



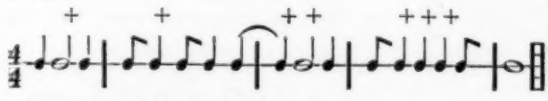
(*c*) E♭ Major.



(*d*) A Major.



5. Place a cross (+) over each syncopated note in the following passage :—



6. Explain (briefly) the following terms :—
(*a*) Legato. Smoothly.
(*b*) Fortissimo. Very loud.
(*c*) Mezzo Forte. Of medium loudness.
(*d*) Leggiero. In a light and bright manner.
(*e*) Accelerando. Gradually quickening the rate.
(*f*) Lento. Very slowly.
(*g*) Presto. Quickly.
(*h*) Crescendo. Gradually increasing in loudness.

### Tonic Sol-Fa Notation.

1. Write (plainly) the following values in four-pulse measure. The figures show duration in pulses or fractions of a pulse. Begin on a strong pulse :—

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1½ | ½ | ½ | ½ | ½ | ½ | ½ | ½ | 1 | ½ | ½ | ½ | ½ | ½ | 1 | 2 | 1 |
| s | m | f | l | r | s | f | REST | m | r | m | f | s | m | r | d | REST |

| | | | | |
|---|---|---|---|---|
| \| s : -.m \| f.l : r., s \| | f. : m | \| r,m,f : s.m \| | r : d | \| — : ‖ |

2. Name the following intervals :—

| | *Answer.* | | *Answer.* |
|---|---|---|---|
| (*a*) | s—f' minor seventh. | (*e*) | d—re augmented second. |
| (*b*) | m—l perfect fourth. | (*f*) | r—ta minor sixth. |
| (*c*) | f—de' augmented fifth. | (*g*) | fe—ma' diminished seventh. |
| (*d*) | r—se pluperfect fourth. | (*h*) | ma—de' augmented sixth. |

3. Re-write the following passages, making a change by bridge-notes at (*a*) and a return to the original key at (*b*) :—

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (*a*) | | | | | | | | | | | (*b*) | | | | |
| | s | d | m | l | r | s | fe | l | d' | m | r | fe | t | l | d | f | r | m | d |
| Ans. | s | d | m | l | ʳs | d' | t | r' | f' | l | s | t | m' | r' | ᶠd | f | r | m | d |
| | | | | | (*a*) | | | | | | | | | | | (*b*) | | | | |
| | m | s | d | m | d' | ta | l | r' | s | ta | m | s | f | l | s | t | d' | | | |
| Ans. | m | s | d | m | ᵈ's | f | m | l | r | f | $t_1$ | r | d | ᵐl | s | t | d' | | | |

4. Write the Minor scale ascending, using the minor 6th and the major 7th and again descending, using the minor 7th and the minor 6th.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Ascending* | l | t | d' | r' | m' | f' | se' | l' |
| *Descending* | l' | s' | f' | m' | r' | d' | t | l |

5. Which one of the following notes is highest in pitch, and which one lowest ?

(*a*) f' in Key C
(*b*) r in Key G
(*c*) $m_1$ in Key B♭
(*d*) $r_1$ in Key A
(*e*) $s_1$ in Key D
(*f*) s in Key F
(*g*) m' in Key E

} m' in Key E is the highest, and $s_1$ in Key D is the lowest.

6. Explain (briefly) the following terms :—
(*a*) Legato. Smoothly.
(*b*) Fortissimo. Very loud.
(*c*) Mezzo Forte. Of medium loudness.
(*d*) Leggiero. In a light and bright manner.
(*e*) Accelerando. Gradually quickening the rate.
(*f*) Lento. Very slowly.
(*g*) Presto. Quickly.
(*h*) Crescendo. Gradually increasing in loudness.

### French.—Men and Women.

Friday, December 21st, 4 to 6.

1. Translate into English :—

(*a*) Cet esprit religieux, cette foi vive, dans une si jeune personne, doivent paraître d'autant plus extraordinaires qu'elle ne les *devait* point à l'éducation. Sans être irréligieux, son père s'occupait peu de prières ; et quoique sa mère *fût* plus exacte à cet égard, elle manquait en général d'instruction, et Prascovie ne devait qu'à elle-même les sentiments qui *l'animaient*.

(*b*) Elle redoubla de vitesse pour atteindre les premières habitations, qu'elle ne croyait pas être fort *éloignées ;* mais un tourbillon de vent ayant renversé un arbre devant elle, la frayeur *lui fit* chercher un refuge dans un bois voisin. Elle se plaça sous un sapin entouré de hauts buissons, pour se préserver de la violence du vent. La tempête dura toute la *nuit ;* la jeune fille la passa sans abri dans ce lieu désert, exposée aux torrents de la pluie, qui *ne cessa que* vers le matin.

(*c*) Elle *mangeait* à la table de la princesse, que son âge et ses infirmités empêchaient souvent de paraître, et n'avait jamais l'occasion de lui parler en particulier. Bientôt les personnes de la société s'accoutumèrent à sa présence et ne s'occupèrent plus d'elle. La jeune étrangère *avait* souvent *fait parler* à la princesse du but de son voyage et de ses espérances ; mais *soit* que cette dame en *regardât* le succès comme impossible, soit que les personnes qui *s'étaient chargées* de lui parler l'eussent négligé, ses prières n'eurent aucun résultat.

(*a*) That religious spirit, that living faith, in so young a person, must appear so much more extraordinary as she was not indebted for them to education. Without being irreligious, her father troubled himself little about prayers ; and although her mother was more particular in this respect, she was generally lacking in education, and Prascovie owed only to herself the feelings which inspired her.

(*b*) She redoubled her speed in order to reach the first habitations, which she did not believe to be far distant ; but a strong gust of wind having rooted up a tree in front of her, fear led her to seek a refuge in a neighbouring wood. She placed herself under a fir-tree surrounded by high shrubs, in order to preserve herself from the violence of the wind. The tempest lasted all the night ; the young girl passed it without shelter in this desert place exposed to the torrents of rain, which ceased only towards morning.

(*c*) She took her meals at the table of the princess, whom her age and her infirmities often hindered from being present, and had never had an opportunity of speaking to her in private. Soon the persons who were present grew accustomed to her presence, and no longer took notice of her. The young stranger had often caused the princess to speak of the object of her journey, and of her hopes ; but whether this lady regarded its success as impossible, or whether the persons who had undertaken to speak to her had neglected it, her prayers had no result.

*Parsing.*

2. (*a*) *Devait*, imperf. ind., 3rd sing. of devoir (devant, dû), agreeing in numb. and pers. with elle.

*Fût*, imperf. subj., 3rd sing. of être (étant, été), gov. in subj. by quoique, and agreeing in numb. and pers. with mère.

*L' = la*, pers. pro., 3rd sing., fem., accusative case, gov. by animaient.
*Animaient*, imperf. ind., 3rd plur. of animer (animant, animé), agreeing in numb. and pers. with qui.

(*b*) *Éloignées*, past part., fem. pl. of éloigner (éloignant, éloigné), agreeing in numb. and gend. with que (= habitations).
*Lui*, pers. pro., 3rd plur., fem., dative case, depending on fit.
*Fit*, past def., 3rd sing. of faire (faisant, fait), agreeing in numb. and pers. with frayeur.
*Nuit*, noun, fem., sing., accusative case, expressing duration of time.
*Ne*, adverb of negation, mod. cessa.
*Cessa*, past def., 3rd sing. of cesser (cessant, cessé), agreeing in numb. and pers. with qui.
*Que*, adverb of mood, modifying cessa.

(*c*) *Mangeait*, imperf. ind., 3rd sing. of manger (mangeant, mangé), agreeing in numb. and pers. with elle.
*Avait*, imperf. ind., 3rd sing. of avoir (ayant, eu), agreeing in numb. and pers. with étrangère.
*Fait*, past part. of faire (faisant, fait), depending on avait, and governing the infinitive parler.
*Parler*, pres. infin. of parler (parlant, parlé), governed by fait.
*Soit*, properly the imperative 3rd sing. of être. With que, it forms the compound conjunction, soit que.
*Regardât*, imperf. subj., 3rd sing., of regarder (regardant, regardé), depending on the conjunction soit que.
*S'étaient chargées*, pluperf. ind., 3rd plur. of the pronominal verb se charger (se chargeant; s'étant chargé), agreeing in numb. and pers. with qui (= personnes).
*Chargées*, past part., fem. plur., agreeing in numb. and gen. with the direct obj., se (= personnes).

3. Il s'est levé de bonne heure.
Le conducteur va partir.
Il est né il y a environ quinze ans.
Elle mourut il y a deux ans.

4.

| *Infin.* | *Pres. part.* | *Past part.* | *Ind. pres., 1st sing.* | *Past def. 1st sing.* |
|---|---|---|---|---|
| Recevoir. | Recevant. | Reçu. | Je reçois. | Je reçus. |
| Voir. | Voyant. | Vu. | Je vois. | Je vis. |
| Loger. | Logeant. | Logé. | Je loge. | Je logeai. |
| Courir. | Courant. | Couru. | Je cours. | Je courus. |
| Coudre. | Cousant. | Cousu. | Je couds. | Je cousis. |

5.

| *Sing.* | *Plur.* |
|---|---|
| Voix. | Voix. |
| Genou. | Genoux. |
| Aïeul. | Aïeuls, grandfathers. / Aïeux, ancestors. |
| Fils. | Fils. |
| *Masc.* | *Fem.* |
| Prophète. | Prophétesse. |
| Pécheur. | Pécheresse. |
| Lion. | Lionne. |
| Aigle. | Aigle. |

6. Cet homme.
L'homme que je vois.
Je vois votre maison, et celle de votre frère.
Je sais que vous êtes l'individu.
Cela est vrai.
Faites comme cela.

## GEOGRAPHY.—Men and Women.

Thursday, December 20, 3.15 to 5.

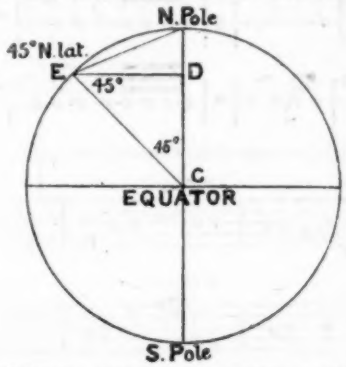
1. Draw a map to show the coast from the mouth of the Ribble to Land's End, and from the mouth of the Boyne to Carnsore Point. Show also Liverpool, Chester, Holyhead, Pembroke, Swansea, Cardiff, Bristol, and Dublin; OR,

Draw a map to show the coasts of the British Isles between latitude 54° and 56°. Show also York, Newcastle, Edinburgh, Carlisle, Glasgow, Belfast, Londonderry.

2. (*a*) What do you understand by the term '*axis of rotation*.'
(*b*) Where in this axis is the centre of the circle of which the Equator is the circumference?
Where in this axis is the centre of the circle of which parallel of North Latitude 45° is the circumference?
(*c*) What do you understand by a '*great circle*,' a '*small circle*,' on the surface of the earth.
(*d*) State briefly why the distinction between great circles and small circles is important for navigators.

(*a*) The term *axis of rotation* means the axis on which the earth turns in its daily motion. It is an imaginary line going through the centre of the earth and coming to the surface at the North and South Poles.

(*b*) The planes in which the circles of latitude lie all pass through the axis of the earth, and their centres lie in this axis. To find the centre of each of these circles, it is necessary to draw a line in the plane of the circle from its circumference to




the earth's axis. This gives the position of the centre of the circle, and the line so drawn is both a perpendicular to the earth's axis, and a perpendicular, or normal, to the curve of the circle of latitude.

Proceeding in this way, we find that the centre of the circle, of which the Equator is the circumference, is situated at C, the centre of the earth. (See diagram.)

The centre of the circle, of which parallel 45° of North Latitude is the circumference, is situated at D in the diagram. If E be situated at 45° from the equator, and EC be joined, the triangle CED is a right-angled triangle, having equal angles of 45° each at E and C. Therefore the side CD = DE, and since the square on CE = the sum of the squares on CD and DE, $CD = \frac{CE}{\sqrt{2}}$. But CE is the radius of the earth. Then D is situated at a distance from C of $\frac{\text{earth's radius}}{\sqrt{2}}$.

(*c*) A *great circle* on the surface of the earth is one whose plane passes through and contains the centre of the earth. Thus the Equator is a great circle, and each of the meridians of longitude extending from pole to pole is the half of a great circle, the other half of which is the corresponding meridian on the other side of the earth's surface.

Any other circle on the surface of the earth is called a *small circle*.

(*d*) The distinction between great and small circles is important to navigators, because by determining a series of points in an arc of a great circle, it is possible to direct a ship's course as nearly as possible on such an arc; that is, on the curve making the shortest distance between the place from which it sets out and that at which it is to arrive. This is called 'great circle sailing.'

3. Name the chief seaports of Wales, and briefly explain the importance of each. Name the great railways which connect England and Wales, their London stations, and their great stations in or near Wales; OR,

State, as nearly as you can, the distance of each of the following places from London, and say what you know of the railway routes between them and London:—Edinburgh, Dover, Southampton, Exeter, Oxford, Derby, Peterborough.

The chief seaports of Wales are:—

*Newport*, at the mouth of the Usk. Exports coal and iron, and imports timber from Norway and America.

*Cardiff*, on the Taff, a town which has enormously increased of late years. It is now the largest town in Wales. Exports great quantities of coal and iron to various parts of England and the Continent.

*Swansea*, on Swansea Bay. Exports large quantities of coal, iron, copper, and tin plate, and imports copper ore in large quantities from Cornwall, Spain, and Australia.

*Milford*, on Milford Haven, imports timber, and exports coal and iron.

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*Model Answers to Questions set in History, as well as remainder of those in Geography, and Domestic Economy, will appear next month.*

# Our Science Section.

## HONOURS PHYSIOGRAPHY NOTES.

BY R. A. GREGORY, F.R.A.S.,
*Oxford University Extension Lecturer, Author of 'Elementary Physiography,' &c.,*
AND
A. M. DAVIES, B.SC. (LOND.), F.G.S.,
*Late Demonstrator in Geology at the Royal College of Science.*

### Solar Prominence Photography.

A description of the method employed by Prof. G. E. Hale for photographing solar prominences, without the intervention of a total solar eclipse, is given in 'Honours Physiography' (p. 57). Dr. Deslandres is working on much the same lines at the Paris Observatory, and has recently published some of his results. It is well known that an ordinary photograph of the sun is mainly produced by the action upon the sensitive plate of the bright intervals between dark lines. Dr. Janssen obtains his remarkable pictures of the sun by using only the rays of light which produce the maximum chemical effect. This practically means that light of one colour is used, for the most actinic rays only extend over a small region (see 'Honours Physiography,' p. 55). Prof. Hale and Dr. Deslandres have carried the principle still further, and have thereby greatly advanced solar physics. The dark lines in the solar spectrum are only dark by contrast, and these observers have shown that sun pictures can be produced by the light from such lines alone. They arrange their spectroscopic apparatus so that sunlight is first decomposed into a spectrum containing the usual dark lines, and then one of these relatively dark lines is isolated and used to act upon a photographic plate. But the lines in the solar spectrum represent various elements, and it is probable that the elements more or less predominate in layers according to their densities. Assuming this, it will be evident that, by isolating a line due to any element, and using it to act upon a sensitive plate, a photograph is obtained of the layer of the sun in which that particular element predominates. Dr. Deslandres has lately exhibited to the Royal Astronomical Society some of the photographs obtained in this way. His first results were produced by means of the light from the bright interval between two dark lines. The pictures thus obtained show the photosphere with spots and faculæ much the same as Janssen's photographs. One point confirmed by the pictures is that the difference between the brightness of the solar disc and that of the spots and faculæ is more marked the greater the refrangibility of the light employed. The bright lines due to the vapour of calcium gave a different set of results. Such reversed lines do not represent incandescent solid or liquid, as in the preceding case, but are emitted by gaseous calcium at a higher level. Their light therefore imprints the image of the chromosphere upon the photographic plate. Photographs of this kind agree with those previously mentioned as regards disposition and general forms of faculæ, but they differ in the fact that they show faculæ near the centre of the disc as clearly as faculæ near the edge, and also by greatly extending the areas of these bright patches. Using the light from a portion of the dark and wide calcium line in the ultra-violet part of the solar spectrum, and exposing the photographic plate a little longer than when the bright reversal in the middle of the line was employed, a curious and altogether different result was obtained. The same faculæ appear upon the photograph, but they are not so clearly marked and are of less extent. On the other hand, spots are shown very distinctly, with their penumbræ sharply defined. Similar photographs have been obtained by using absorption lines of iron, aluminium, and carbon, which are wide enough to permit them to be isolated by means of the spectrograph.

### The Planet Jupiter.

During the few ensuing months (writes Mr. W. F. Denning in *Nature*) the observation of the belts and spots on the planet Jupiter will enlist a large amount of attention, for there is probably no other planetary object which exhibits a more diversified and variable aspect. One feature of the observations will be important in enabling comparisons to be made as to the rates of motion of the various white and dark spots during this and preceding oppositions. No doubt many of the surface markings now existing are identical with those observed some years ago. From 1878 to 1882 the prominent apparition of the red spot incited observers to fully investigate the phenomena of the different formations, and they were found to be very discordant in their rates of velocity. The red spot and equatorial white spots were evidently subject to a marked retardation, causing their rotation periods to increase with the time.

As to the red spot, the slackening rate of motion it exhibited in the earlier years of its presentation appears not to have been maintained since 1886. There have been, it is true, some marked deviations from the mean rate, for in the years from 1886 to 1890 the motion became accelerated and corresponded to a rotation period of about 9 hrs. 55 mins. 40·2 secs., but in the three following years it slackened again, and since 1891 the period has been about 9 hrs. 55 mins. 41·5 secs.

At the present epoch, the spot is extremely feeble in its visible outlines, but on a really good night its elliptical form can be distinctly traced, and it does not appear to have materially changed either in its shape or dimensions since 1879. Its southern borders have lately been conjoined with a grey belt in about latitude 30° south. The commingling of the spot and belt has been noticed here on previous occasions, and it is certain that on its southern side the spot exerts very little of the repellent influence so often ascribed to it.

### Work for February.

Read Chapters II. and V. of 'Honours Physiography.' In connection with the former, look through Chapters X. and XII. of 'Advanced Physiography.' Note particularly the sections in the Honours book on classification of stellar spectra (p. 35); on photographs of stellar spectra (p. 38); and on spectroscopically double stars (pp. 41–45). The sections which should be carefully read in Chapter V. are: permanence of the great oceanic areas and secular movements of the sea (pp. 111–116). Attention should also be given to the general run of the statistics in the section on the composition of the oceanic waters (p. 102). After becoming familiar with the contents of the two chapters set for reading, write out answers to the following questions:—

1. Give an account of recent researches in connection with the photographic spectra of the brighter stars.
2. What are spectroscopic double stars, and how have they been discovered?
3. Describe the relations between new stars, comets, and nebulæ.
4. How have stars been classified in relation to their spectra?
5. Describe briefly the changes of spectra which take place, according to the meteoritic hypothesis, during the condensation of a nebulæ.
6. Give an account of the results which have been obtained by recent researches in connection with the amount and the effects of the great pressure to which the lower layers of the oceanic waters are subjected.
7. What are the chief views held with regard to the permanence of great oceanic areas?
8. Give an account of recent investigations with regard to the composition of sea-water.
9. Give an account of the deep-sea deposits, and describe briefly their distribution according to depth.
10. Discuss the probable causes of the oceanic circulation.

Students who intend to present themselves for the examination in either Advanced or Honours Physiography next May will derive benefit by trying their strength upon the subjoined paper, set for the recent Training College examination in the subject. Model answers to the questions will be given later.

### Second Stage or Advanced Examination.

Five questions may be attempted, three from one series and two from the other.

*Series I.*

1. Define fully (by diagram or otherwise) the meanings of the following terms:—

| | | |
|---|---|---|
| Gibbosity. | Elongation. | Opposition. |
| Conjunction. | Stationary points. | Synodic period. |

2. If the earth's orbit* were perpendicular to the plane of the ecliptic, what changes would this give rise to in—
(*a*) The apparent daily movements of the stars.
(*b*) The seasons.
(*c*) The length of day and night.

3. What do we know about the atmospheres of the Moon, Mars, and Jupiter?
State the methods employed to detect the existence of such atmospheres.

4. What explanations have been put forward to account for the phenomena of Variable Stars?

*Series II.*

5. State what you know concerning the crystalline form, chemical composition, physical properties, and mode of occurrence of the following minerals :—
(*a*) Magnetite.
(*b*) Calcite.
(*c*) Rock-salt.
(*d*) Graphite.

6. (*a*) What special form of instruments are used for determining the temperature of the earth's crust?
(*b*) How are observations on earth-temperatures carried on in mines and tunnels?
(*c*) How are observations on earth-temperatures made in bore-holes and wells?
(*d*) What are the general results obtained by these observations?

7. State what you know concerning :—
(*a*) The amount of pressure of oceanic water at a depth of 3,00 fathoms.
(*b*) The influence of this pressure on the density of the water on the ocean floor.
(*c*) The effects produced by this pressure in determining the level of the general surface of the ocean.
(*d*) Its effect on organisms living on the ocean floor.

8. What are the chief peculiarities in the climate of the British Isles, and to what causes are these peculiarities to be ascribed?

### Honours Examination.

*All, or any, of the questions may be attempted.*

1. State the different kinds of stellar spectra which have been recognised, and name some stars which have spectra closely resembling that of the sun.

2. Name the magnetic elements and state how they are observed at any place.

3. State what you know concerning the characters and mode of origin of oolitic limestones.

4. Give an account of the chemical composition and mineralogical constitution of the chief varieties of lava.

5. Give an account of the recent researches in connection with one of the following subjects :—
(*a*) The surface markings of Mars.
(*b*) The occurrence of crystallised carbon in meteorites and in the earth's crust.

### The Mechanics and Physics of Igneous Intrusions.

A great many facts have been accumulating during recent years that tend to give greater precision to our ideas as to the relations of igneous rocks to those among which they have intruded. One of the greatest advances made in this direction is due to Mr. G. K. Gilbert's study of the remarkable district of the Henry Mountains in Southern Utah. These mountains form an isolated group (not a range) in the arid cañon district—a region that by its freedom from subaërial erosion has furnished so much valuable evidence on earth-movements and other geological subjects. The strata of the whole region are practically horizontal, though crossed by long lines of *monoclinal* flexure. The Henry Mountains owe their existence to the elevation of these horizontal beds into a series of dome-like protuberances, circular or slightly oval in plan. Owing to the unequal denudation of the various domes of the group, their internal structure could be made out in a most complete manner. It was found that the strata had been arched up into these domes by great masses of trachyte which had accumulated at various levels beneath, resting on undisturbed beds below. They in fact resemble the trachyte *puys* of Auvergne (*Elem. Physiog.*, pp. 220, 221), with the distinction of being developed underground. To these masses Mr. Gilbert gave the name of *Laccolites*. Laccolites may be regarded as underground volcanoes, or rather *puys*. A vertical section across a laccolite would show that as the beds curve up at the edge of the laccolite they present a convex surface towards it, while where they arch over it they present a concave surface to it. Obviously the conditions of strain of these two portions are different, and in accordance with this it is found that the beds above the laccolites are penetrated by an abundance of vertical *dykes*, while at the sides intrusive *sheets* or *sills* (relatively horizontal) are intercalated between the beds. The mention of *sills* suggests a comparison between these structures, long known, and *laccolites*. The difference is only one of degree, for an intrusive sheet, however thin, must arch up, even though it also compresses, the overlying beds, to a degree which is dependent on its thickness as compared with its lateral extension.

The question of the determining causes of the particular level at which the lava ceases to rise vertically and begins to spread out laterally has been fully discussed by Mr. Gilbert—at least, for the case of laccolites in horizontal beds, like those of the Henry Mountains. He points out that there are two determining causes—(1) the tendency of the lava to hydrostatic equilibrium, according to which it would rise until it reached such a point that the average density of the beds above it was less, and that of the beds below it greater than its own; and (2) the relative resistance offered by the rigidity of the strata to its vertical and lateral extension respectively.

The first of these causes can of course only operate when the density of the fluid lava is equal to that of a rather light sedimentary rock. Were there no rigidity in the strata, such a lava would necessarily rise to the proper level by the mere weight of the superincumbent heavier strata. But unless the lava is very much lighter than the strata the rigidity of the latter would probably be sufficient to prevent its rise at all, in the absence of any pressure originating elsewhere—laterally, for example. Unfortunately, too little is known of the densities of fused igneous rocks. Solidified igneous rocks are, on the average, denser than sedimentaries, but when fused their density would diminish more rapidly with increasing temperature than would that of the infusible shales and sandstones with which they have to be compared.

On the whole, it is evident that the combined effects of relative density, relative rigidity, and external pressure (external, that is, to the rock-masses under consideration) must be very complex. In the Henry Mountain region the problem is simplified by the last of these three being at a minimum. Such a case is very exceptional, and, as we shall see, in other cases the last may be the main determining cause.

### Laccolites in England.

Mr. Gilbert, in first describing laccolitic structure, predicted that it would be found to exist in many cases where it had been unsuspected before the key was found in the unusually simplified area of Western America. In more disturbed districts it is more difficult to prove a particular igneous intrusion to be laccolitic. It has been suggested that many of the great granite 'bosses' which were generally supposed to owe their position to an actual displacement or absorption of great masses of strata, might really be only the exposed cores of great laccolitic domes. This was suggested by Mr. Ussher for the Dartmoor and Cornish granites, and though this view has since been abandoned by its author, it is still held by other geologists. Professor Sollas has made a similar suggestion for the great granite intrusion of Leinster. These, however, are only hypotheses, supported by certain facts, but not in any way proved. The first case in which laccolitic structure was proved in Britain was that of Corndon Hill, on the borders of Shropshire and Montgomery. This appears on the geological map as a circular mass of dolerite, and was shown in old geological sections as a pyramidal 'boss,' increasing in breadth from above downwards—the customary representation of intrusions other than actual sills. Mr. W. W. Watts has, however, proved it to be a laccolite, by actually finding an exposure of the floor of relatively undisturbed strata on which it rests. Several other laccolites have also been found in the same district of Shropshire. Unlike those of the Henry Mountains, they are intimately connected with the folding that the district has suffered, and stand to it in the relation of effect rather than of cause. Thus the Corndon dolerite was forced by hydraulic pressure into the summit of an anticlinal fold, the particular plane of intrusion being determined by the occurrence of a firm bed of compacted volcanic ash above one of soft shale, the two probably undergoing differential bending under the action of the pressure that produced the fold—the hard ash-bed bending as a whole, while the soft shale crumpled irregularly, so affording opportunity for the intrusion. In the case of some neighbouring laccolites, Mr. Watts regards the determining plane of the laccolitic intrusion as the unconformable junction of two series of sedimentary rocks (Ordovician and Silurian).

* This is evidently a misprint for 'equator,' or 'axis.'

It is notable that in this district the laccolites are of dolerite, a basic rock, much heavier than the Henry Mountain trachyte; and, further, that acid rocks as light as the latter are also found in Shropshire, but as volcanic products,—lava-flows and ashes—not laccolites. According to Mr. Harker, the same is true of the igneous rocks of North Wales—the acid form lavas, the basic intrusive sheets and laccolites. This illustrates a corollary to the principles already stated, that, other things being equal, a lighter rock is more likely to reach the surface and form a volcano, a heavier one to form an underground laccolite. But that other things are not always equal is proved by the fact that in the Old Red Sandstone series of Scotland, according to Sir A. Geikie, the sills are more acid than the lava-flows. This may be due to the fact that the former are later in date than the latter, and were intruded under a cover of sedimentary rocks which had not only become much thicker, but also had its planes of weakness cemented up by the solidified lava that had been squeezed through them at an earlier date.

### Dykes.

In Shropshire not only are the comparatively horizontal laccolites determined by the folding of the district, but so are also the vertical intrusions—dykes. Mr. Watts finds that some are intruded along fault-planes, others along planes of sharp bending. In one case a line of strain is marked by a discontinuous series of parallel dykes arranged in a stair-like manner. Some of these dykes appear to have been the feeders of the laccolites. Such may be the case also with some dykes in the Henry Mountains, but there the majority are, as already mentioned, found in the tensional area above the laccolites.

Some dykes may be the feeders of 'fissure-eruptions,' *i.e.* the outpouring of great sheets of lava over wide areas without the formation of volcanic cones; while there are others whose upward termination has been found some way beneath the surface. The former usually have produced more marked metamorphism on the rocks they traverse than the latter, since they represent a channel along which a continual flow of highly heated lava has taken place instead of a single injection that must at once have commenced to cool. Dykes may often be found along fault-planes; even when not so, they probably represent planes of yielding under tension. How far they may have displaced and absorbed part of the rocks they cut through, how far have compressed them on either side, and how far have filled an actual cavity, is difficult to settle. That the first of these processes does not occur to an important extent may be concluded from the uniform chemical composition of dykes cutting through a great variety of rocks: this could not be the case if any considerable bulk of the adjacent rock were absorbed.

### Granite Margins.

In certain cases, however, igneous rocks must unquestionably swallow up part of the rock they cut through. Sometimes blocks of slate, etc., are found actually enveloped in granite, and in these cases it is interesting to note how little of the slate may have been fused, and how only a narrow zone around it is in any way different from the main mass of granite. Mr. J. G. Goodchild has recently described the margin of the Ross of Mull granite. He finds it difficult to say where the boundary of the granite should be drawn, for while the neighbouring rocks are penetrated by numerous veins from it, it is itself, near the margin, full of enclosed lumps of these rocks; and no sharp line can be drawn between the one condition and the other. He considers that in the more central parts these blocks undergo complete fusion, and their material permeates the igneous rock. The fact, however, that such striking phenomena are to be seen on the granite margin in such a case, affords some support to the view that where no such included blocks are found the granite may be laccolitic.

### Origin of the English Lakes.

Although, as explained last month, the alternative theory to the glacier-erosion of the Alpine lakes is their formation by earth-movements, this cannot apply to districts like North Wales or Westmoreland, where no extensive recent earth-movements have occurred. Some of the English and Welsh lakes are known to be dammed up by glacier-moraines, but there are others where the stream issues from the lake over solid rock. These have hitherto been considered striking examples of glacial erosion, but within the last month or two Mr. J. E. Marr has, as the result of extensive observations, expressed the opinion that in some such cases at least the course of the stream has been diverted to its present course by a moraine-dam, though it does not flow over it.

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# MAGNETISM AND ELECTRICITY.

## FOR THE ADVANCED STAGE OF THE SCIENCE AND ART DEPARTMENT COURSE.

BY EDWIN EDSER, A.R.C.S.

*Assistant in the Physical Laboratory, Royal College of Science; Member of the Physical Society.*

### *Magnetism.*

Chapters VII., VIII., and IX., and the calculation on pp. 173–6 should be carefully read, special attention being paid to the latter. These chapters practically cover the ground prescribed for the advanced course; it may, however, prove useful to the student to have some questions which have been set in recent years fully worked out.

'A bar magnet is suspended horizontally in the magnetic meridian by a wire without torsion. To deflect the bar 10° from the meridian the top of the wire has to be turned through 180°. The bar is removed, re-magnetized, and restored, and the top of the wire has now to be turned through 250° to deflect the bar as much as before. Compare the magnetic moments of the bar before and after remagnetization.' (1894.)

In both cases the suspended magnet is acted upon by two couples, tending to twist it in opposite directions. When it is at rest, these must be equal, and by equating them we obtain a method of measuring the relative magnetic moments in the two cases.

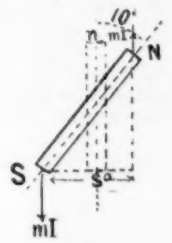



Fig. 1.

For the magnet to be, in the first case, suspended in the earth's magnetic field without torsion of the wire, it must lie along the lines of force. Let *ns* (fig. 1) denote this first position. The top of the wire is now turned through 180°, and the magnet assumes the new position NS, being deflected through 10° from its previous position.

If K = couple when the wire is twisted through 1°, then the couple when it is twisted through D° = K × D.

Now the end N of the magnet is acted on by a force *m*I in the direction of the lines of force, where *m* = pole strength of magnet and I = intensity of the field. Also, the end S of the magnet is acted on by an equal force in the opposite direction. Therefore the restoring couple = *m*I × *a*, where *a* = the arm of this couple, *i.e.*, the perpendicular distance between the lines of action of these two forces. But if the magnet has turned through 10°, *a* = *l* × sin 10°, where *l* = distance between poles of magnet.

∴ Magnetic restoring force = *ml*I sin 10° = *ml*I sin 10° = MI sin 10°,
where M = *ml* = magnetic moment of magnet (see p. 140).

Also, top of wire has rotated through 180°, and magnet has rotated through 10°, ∴ twist on wire = 180° − 10° = 170°.

$$\therefore \text{MI sin } 10^\circ = 170 \times \text{K}. \qquad (1)$$

Similarly, after remagnetization, magnetic restoring force = M′I sin 10°, M′ being the new value of the magnetic moment of the magnet.

Also, twist on wire = 250° − 10° = 240°.

$$\therefore \text{M}'\text{I sin } 10^\circ = \text{K} \times 240. \qquad (2)$$

Dividing (2) by (1), we get—

$$\frac{\text{M}'\text{I sin } 10^\circ}{\text{MI sin } 10^\circ} = \frac{\text{M}'}{\text{M}} = \frac{\text{K} \times 240}{\text{K} \times 170} = \frac{24}{17}.$$

$$\therefore \frac{\text{M}'}{\text{M}} = \frac{24}{17}.$$

'Show that the force exerted by a bar magnet, of magnetic moment M, on a unit pole placed at any point in the plane which bisects the magnet at right angles in $\text{M}r^{-3}$, where $r$ is the distance of the point from either pole, it being assumed that the magnetic strength of the magnet is concentrated at its poles. How may this result be applied in the comparison of the horizontal component of the earth's magnetic field at different points?' (1894.)

Let NS (fig. 2) represent the magnet, and $p$ the position of the unit pole at distance $r$ from either pole of the magnet.

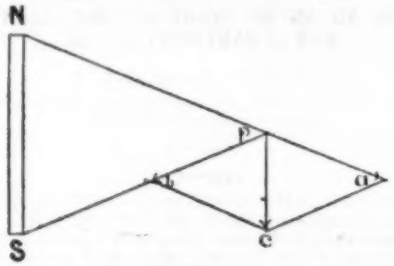



FIG. 2.

Then the unit pole will be subjected to a repulsion, in the direction of N$p$, equal to $\frac{m \times 1}{r^2}$, and an attraction, in the direction $p$S, equal to $\frac{m \times 1}{r^2}$ ($m$ being the strength of either of the equal poles N or S).

Draw $pa$ and $pb$ representing, in direction and magnitude, the repulsion and attraction respectively. Then the resultant force is found by completing the parallelogram $pacb$ and drawing the diagonal $pc$.

Also, from Euclid, $\frac{pc}{pa} = \frac{NS}{Np} = \frac{l}{r}$, if $l$ = length of magnet.

$$\therefore \text{Resultant force} = pc = pa \times \frac{l}{r} = \frac{m \times 1}{r^2} \times \frac{l}{r} = \frac{ml}{r^3} = \frac{M}{r^3},$$

M being the magnetic moment.

This result may be applied in the comparison of the horizontal component of the earth's magnetic field at different points as follows :—

FIG. 3.

A small magnetic needle is hung by a fine silk fibre, the absence of torsion allowing it to take up its position along the earth's magnetic lines of force at the point. Let this position be $ns$ (fig. 3). The large magnet NS is now placed some distance from it, and at right angles to the direction of the earth's field at the point. The suspended needle $ns$ will be deflected through some angle, say $\theta$, to the position $n's'$. We must now equate the couples acting on the needle. Force on $n'$ in westerly direction $= \frac{m'M}{r^3}$, $m'$ being the pole strength of suspended needle. As the length of the latter is very small, the distance of either of its poles from N or S may be supposed equal to $r$. Then force acting on $S' = \frac{m'M}{r^3}$ in opposite direction to force on $n'$.

Therefore couple tending to twist suspended needle in direction contrary to that of the motion of the hands of a watch $= \frac{m'M}{r^3} \times a$, where $a$ = arm of couple $= l' \cos \theta$, $l'$ being length of suspended needle.

Also, if I = magnetic field due to the earth, couple tending to twist suspended needle in direction of motion of hands of watch $= m'I \times l' \sin \theta$.

For equilibrium $\frac{m'M}{r^3} \times l' \cos \theta = m'I \times l' \sin \theta$.

$$\therefore \frac{M}{r^3} \cos \theta = I \sin \theta.$$

$$\therefore I = \frac{M}{r^3} \cot \theta.$$

Thus by placing the large magnet always at the same distance $r$ from the small one, the only variable will be $\theta$, the angle of deflection of the suspended needle. The strength of field at the various places will then vary as cot $\theta$.

'A bar magnet, hung horizontally by a fine wire, lies in the magnetic meridian when the wire is without twist. It is then found that when the top of the wire is twisted through 120° the magnet is deflected through 30°. Through what further angle must the top of the wire be twisted in order to turn the magnet perpendicular to the magnetic meridian?' (1893.)

As in the first example, we get—

$$MI \sin 30° = K(120° - 30°) = K \times 90.$$
$$MI \times \tfrac{1}{2} = K \times 90. \qquad (1)$$

Let $x$ = the *further* angle of torsion necessary to deflect needle through 90°. Then

$$MI \sin 90° = MI = K(120 + x - 90) = K \times (x + 30) \qquad (2)$$

Dividing (2) by (1), we get—

$$\frac{MI}{MI \times \frac{1}{2}} = 2 = \frac{K(x + 30)}{K \times 90} = \frac{x + 30}{90};$$

$$\therefore x + 30 = 180; \qquad \therefore x = 180° - 30° = 150°.$$

The further angle necessary is therefore 150°.

*Electricity.*

The next subject to engage our attention is that of Voltaic Electricity, or the study of electricity in motion. We have already had occasion to remark that when two bodies, one charged with positive and the other with negative electricity, are joined together by a metallic conductor, the electricity flows from the one at the higher to that at the lower potential. What electricity exactly *is* we are not in a position as yet to say; but it can be shown that the electricity obtained by rubbing a glass or ebonite rod with flannel or catskin is essentially like that which flows when the two poles of a galvanic cell (such as a Daniell or Leclanché) are connected together. For we can charge a condenser by means of Voltaic cells, and it will behave in every respect as if it had been charged with electricity obtained by frictional or other statical means. Moreover, one of the most characteristic properties of Voltaic electricity is that if a current be passed through a conducting wire held near a suspended magnet, the latter will in general be rotated precisely as if a magnet had been brought into its neighbourhood. But the same result can be obtained if the terminals of a Wimshurst machine be joined to the wire; so that in this respect also the properties of the two kinds of electricity are identical.

The difference of the instruments used in the study of statical (or frictional) and dynamical (or Voltaic) electricity should be carefully remembered. In frictional electricity the attraction or repulsion exerted between two charged bodies is used to measure or indicate the potential of the body, or the quantity of electricity condensed on it. The best-known instruments of this kind are the *Gold Leaf Electroscope* and the *Quadrant Electrometer*. In Voltaic electricity, the current flowing through a wire is measured by the magnetic field which is produced around it. From what we have already done in the study of magnetism there will be no difficulty in conceiving how this magnetic field could be measured by means of the deflection a of small suspended magnet. Instruments designed to measure the strength of currents in this manner are called *Galvanometers*.

The following laws relative to the direction of the lines of force near wires carrying currents may be found useful :—

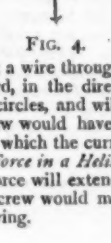



FIG. 4.

Let $ab$ (fig. 4) represent a wire through which a current is flowing from $a$ to $b$ (*i.e.*, downward, in the direction of the arrow). Then the lines of force will be circles, and will extend in the direction in which a right-handed screw would have to be rotated in order to force it in the direction in which the current is flowing.

*Direction of Lines of Force in a Helix.*—Looking at either end of the helix, the lines of force will extend through it in the direction in which a right-handed screw would move, if rotated in the same sense as the current is flowing.

It must be borne in mind that a line of force extends in the direction in which a unit N pole would move if it were left to itself. Consequently, if a small magnetic needle be placed at a point in a uniform magnetic field it will set itself with its N pole pointing along the lines of force. The earth's lines of force, therefore, run from south to north ; in England and the northern hemisphere they moreover dip downwards.

*Questions.*

1. If a soap bubble be electrified, it becomes enlarged. How would you explain this phenomenon ?

2. A small magnetic needle is suspended by a torsionless fibre in the earth's field. A large permanent magnet is now placed with its centre at a distance *d* to the north of the needle, and with its N pole pointing to the east. The deflection of the suspended needle is noted. The same permanent magnet is then placed with its centre at a distance *d* to the *east* of the suspended needle, but pointing in the same direction as before, and the deflection of the needle again noted. What should be the ratio of these two deflections ?

3. A magnetic needle suspended in the earth's field (assumed to be ·18 lines per square centimetre) completes one vibration every two seconds. It is then removed to a point near a dynamo-electric machine, and is found to complete one vibration in half a second: what is the number of lines of force per square centimetre at the latter point ?

## ORGANIC CHEMISTRY NOTES.

By J. T. Hewitt, M.A., D.SC., PH.D.,
*Professor of Chemistry, People's Palace.*

In the last set of notes we considered some of the formulæ which had been proposed for benzene. The evidence adduced in support of these is of two sorts—chemical and physical. To the former belong the researches of Baeyer on the reduction of the phthalic acids and Bamberger's work on the reduction of naphthalene and quinoline derivatives ; to the latter the thermochemical work of Thomsen and the optical measurements of Brühl.

Baeyer's first results led him to the centric formula. In a later paper (*Annalen*, cclxix. 145–206) he says that the benzene nucleus can exist in two modifications, and that every individual benzene compound possesses a settled formula, derived either from that of Claus or from that of Kekulé. Phthalic acid, for instance, is to be formulated with only single linkages, whilst in phloroglucin the linkages are alternately single and double, as in the benzene formula of Kekulé.

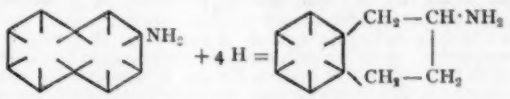
Bamberger has chiefly concerned himself with the reduction of compounds which are generally looked upon as having two aromatic nuclei, two carbon atoms being common to each nucleus. The student should refer to the proofs of the constitution of naphthalene, viz., by Graebe's method, which depends on the oxidation of α-naphthoquinone to phthalic acid, and its conversion by phosphorus pentachloride into pentachlornaphthalene, which yields tetrachlorphthalic acid on oxidation ; and secondly, the simpler proof of Reverdin and Nölting, who found that when nitronaphthalene is oxidised, nitrophthalic acid is formed, whilst if the same nitronaphthalene be reduced to amidonaphthalene the amidonaphthalene yields phthalic acid and not amidophthalic acid on oxidation. Bamberger has attempted to show that we must not look on naphthalene as containing two benzene nuclei having two carbon atoms in common, but that the naphthalene nucleus must be looked on as a whole, capable of yielding one benzene nucleus under certain circumstances. Thus β-naphthylamine and β-naphthol differ largely in their properties from aniline and phenol ; on reduction, 4 atoms of hydrogen are taken up, and the compounds then behave as if they were derivatives of benzene, in which substitution of $NH_2$ or OH for hydrogen had taken place in the side chain. Take the example of tetrahydro-β-naphthylamine; this compound strongly resembles phenylethylamine, $C_6H_5.CH_2.CH_2.NH_2$. Both compounds give stable nitrites which, on heating, give nitrogen, water, and an unsaturated hydrocarbon. Thus—

$$C_6H_5.CH_2.CH_2.NH_2,HNO_2 = N_2 + 2H_2O + C_6H_5.CH = CH_2.$$

and $C_6H_4\begin{cases}CH_2-CH-NH_2,HNO_2\\ CH_2-CH_2\end{cases}$

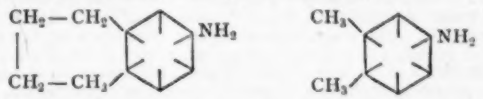
$$= N_2 + 2H_2O + C_6H_4\begin{cases}CH=CH\\ CH_2-CH_2\end{cases}$$

Other properties of the two compounds are similar. This is best explained by supposing the two compounds to be similarly constituted. The original β-naphthylamine differs, however, from aniline so markedly that we can hardly imagine it to be a benzene derivative. Thus we are led to the conclusion that though naphthalene derivatives are not to be regarded as derived from benzene, yet they may be made to yield benzene derivatives. The change on reduction of the compound we have taken may be expressed by the equation—



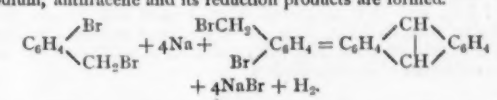
In the same way, if the left-hand half of the naphthalene nucleus were reduced, we should expect to get a compound similar to xylidine in its properties. This is actually the case.

We can exhibit this by a comparison of formulæ.



Bamberger has extended his formulæ to the cases of the isomeric hydrocarbons anthracene and phenanthrene, $C_{14}H_{10}$.

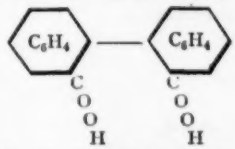
The best proof of the constitution of anthracene is that given by Jackson and White. When orthobrombenzyl bromide is heated with sodium, anthracene and its reduction products are formed.



$$+ 4NaBr + H_2.$$

As the $CH_2Br$ and Br groups are ortho to one another in both nuclei, so the two CH groups in anthracene must be ortho to one another with respect to both benzene nuclei. Note in this connection that the syntheses of Baeyer and Caro of anthraquinone and its hydroxy derivatives, by condensation of phthalic anhydride with benzene and phenols, only prove the ortho position with regard to one nucleus.

The proof of the constitution of the isomeric phenanthrene depends on the fact that oxidation converts it into phenanthrene quinone $C_{14}H_8O_2$, and finally into diphenic acid.



That diphenic acid is really diphenyl-dicarboxylic acid was shown by Schultz and Anschütz, who reduced meta-nitrobenzoic acid to hydrazobenzene dicarboxylic acid, $C_6H_4(COOH).NH.NH.C_6H_4(COOH)$; this gave benzidine-dicarboxylic acid on treatment with hydrochloric acid, and finally, by elimination of the $NH_2$ groups, diphenic acid was obtained. The nitrogen atoms and the carboxyl groups must remain meta to one another, and as in benzidine we have the linkage connecting the phenyl groups para to the two amido groups, it must be ortho to the two carboxyl groups. Thus diphenic acid must have the above constitution.

The physical work on the constitution of benzene has led to discrepant results. Julius Thomsen determined the heat of combustion of many organic compounds, and deduced the thermal values of single and double linkages between carbon atoms; from the heat of combustion of benzene he deduces that the benzene molecule has its carbon atoms bound together by nine single linkages, as in Claus's or Ladenburg's formulæ. (*Ber.* xiii. 1808.)

On the other hand, Brühl has compared the refractive power of benzene with that of other hydrocarbons, and finds that the experimental numbers agree best with the assumption of three single and three double linkages, as in the formula of Kekulé. (*Annalen*, cc. 93). Brühl has worked again at this question, and a few months back published a paper giving determinations of the molecular volume and molecular refraction of benzene and its reduction products on the one hand, and of isomeric open-chain hydrocarbons on the other. By the reduction of benzene, dihydro-, tetrahydro-, and hexahydrobenzenes are successively obtained, and these contain respectively two, one, and no double linkages. Each successive double linkage which disappears by the addition of two hydrogen atoms is accompanied by a regular increase in molecular volume and molecular refraction. Almost exactly the same difference is observed by reduction of benzene to dihydrobenzene, as when the dihydrobenzene is

reduced to tetrahydrobenzene and this latter compound to hexahydrobenzene. Thus Brühl concludes that there are three double linkages in benzene, which successively disappear as each two atoms of hydrogen are added. (See *Ber.* xxvii. 1065.)

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The student who is preparing for the Practical Examination of the Science and Art Department will notice that in the Advanced Stage he has to answer a paper on the principles of organic qualitative analysis, and on the methods of preparation of some organic compounds. It will be well, therefore, not to confine his attention solely to the qualitative analysis, but also to prepare a few organic compounds, such as ethyl acetate, ethyl iodide or bromide, acetone, stearic acid from fat, nitrobenzene, and aniline. The practical skill in manipulation so gained will fully repay the time expended. Two points the student should be careful about—the *purity* and the *yield* of his product. If the substance is liquid or solid take care that it boils or melts at the proper temperature, also weigh the amount of substance obtained and compare the quantity with that theoretically obtainable. This preparation of organic compounds applies even more strongly to the Honours Stage, where part of the practical examination consists of preparation of specimens, separation of organic compounds by distillation, fractional solution or crystallisation, and isolation of products of decomposition.

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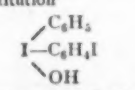
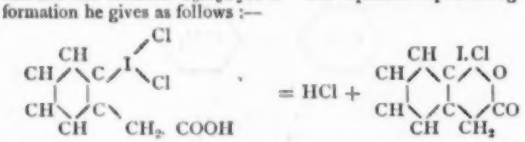
*Recent Work.*—Amongst papers which are of interest may be mentioned one from Prof. Victor Meyer's laboratory by Wilhelm Raum (*Ber.* xxvii. 3232). Professor Meyer discovered some time ago that iodobenzene gave an addition product with chlorine, $C_6H_5ICl_2$, and this compound when treated with potash gives iodosobenzene, $C_6H_5IO$. Last year Prof. Meyer and Dr. Hartmann acted on this substance with sulphuric acid, and obtained the sulphate of a base of the constitution



They also obtained the parent base I $(C_6H_5)_2OH$. These 'iodonium' bases resemble thallium hydroxide in properties, the halogen salts and sulphides are insoluble in water, as are also the chromates; the nitrates and sulphates are however soluble. Raum has now prepared the chloride of orthoiodophenylacetic acid, and finds that it loses hydrochloric acid on agitation with cold water; the product, which is a white powder and melts at 119°, still contains chlorine and has the formula $C_8H_6O_2ClI$. The equation representing its formation he gives as follows :—



The compound is very interesting, not only as an example of trivalent iodine, but also of a closed ring of which an iodine atom is one of the members.

The December number of the *Journal of the Chemical Society* contains much interesting reading in the papers of Prof. W. H. Perkin, jnr., and his students; the remarks on the relative ease or difficulty with which tri-, tetra-, penta-, and hexa-methylene rings may be converted into open chain compounds are of especial importance. The January number of the same journal contains eight papers, seven of which deal with organic compounds; on page 48, Fenton describes a new way of preparing dihydroxy tartaric acid, which he says might be used as a test for sodium compounds. He says: 'A few crystals of the acid are dissolved in a drop of water on a watch glass, the solution to be examined is added, and the liquid neutralised, if necessary, with a drop of ammonia. On stirring with a rod, the white crystalline precipitate appears, usually in lines, as in the detection of potassium by tartaric acid or by platinic chloride.' The test works easily with 1% NaCl solutions, and potassium and ammonium salts do not seem to interfere.

*Questions for Advanced Stage.*—1. What explanation has been given of the existence of three isomeric xylenes? 2. How would you obtain the following compounds from benzene, viz., nitrobenzene, aniline and phenyl hydrazine? What use is made of the last named as a re-agent? 3. Define *amine*, *acid amide*, and *amido acid*. How is glycocoll prepared. 4. Give reasons for stating whether nitroglycerine and nitronaphthalene are correct names or not for the compounds obtained by the action of a mixture of sulphuric and nitric acids on glycerine and naphthalene respectively.

*Questions for Honours Stage.*—1. Give the various formulæ which have been proposed for benzene, discussing their relative values. 2. How have the constitutional formulæ of naphthalene, anthracene, and phenanthrene been determined? 3. What methods have been employed for the determination of the molecular weights of compounds which cannot be volatilised. 4. Describe shortly Pasteur's researches on the isomeric tartaric acids: how may this isomerism be explained?

The Honours student is recommended to read up the organic colouring matters; much about them will be found in Bernthsen's book, and a more detailed knowledge from Prof. Nietzki's 'Chemistry of the Organic Dye Stuffs' (translation by Collins). Some notes on these substances will appear in a later article.

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# MATHEMATICS.

## STAGES 2 AND 3, SCIENCE AND ART DEPARTMENT.

By G. A. Baxandall,

*Assistant Mathematical Instructor, Royal College of Science, London.*

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### Stage 2.

*Algebra.*

In connection with the subject of Simultaneous Quadratic Equations, we drew attention to two types last month. There is another type whose solution requires that we shall be on the look-out for factors. Thus, if we have $x^3-y^3=37$ (1), and $x^2+xy+y^2=37$ (2), we can write (1) as $(x-y)(x^2+xy+y^2)=37$; which by using (2) gives us $(x-y)(37)=37$, or $(x-y)=1$ (3), which can be taken along with (2), and solved by the method of substitution.

*Example.*—Solve $(x-4)(y-4)=8$ (1); $x^2+y^2=100$ (2).

Multiply out in (1), then

$$xy-4(x+y)+16=8;$$
$$\therefore 2xy-8(x+y)=-16.$$
$$x^2+y^2=100;$$
$$\therefore x^2+2xy+y^2-8(x+y)=84.$$
$$(x+y)^2-8(x+y)-84=0.$$
$$(x+y-14)(x+y+6)=0;$$
$$\therefore x+y=14, \text{ or } -6;$$

two equations, each can be taken along with $x^2+y^2=100$, and solved by the method of substitution.

*Read* Chapter XXV., H.S., or Arts. 281, 282, H.K.

*Work out* H.S. Exs. CXIX. 16, 18; Exs. CXX., 5, 10; Exs. CXXI., 3, 8, and Exs. CXXII., 7, 20, 33; *or* H.K. Exs. XXXI.g., 8, 11, 13, 22, and Exs. XXXI.h., 2, 8, 16, 21.

*Example.*—Solve $2x^2+2x+2\sqrt{2x^2-7x+6}=5x-6$.

*Solution.*—In some examples the quantity under the root-symbol can be made from the rest of terms. Thus, by transposing the $5x$ and adding 6 to both sides, we get

$$2x^2-7x+6+2\sqrt{2x^2-7x+6}=-6+6=0; \text{ or}$$
$$(\sqrt{2x^2-7x+6})(\sqrt{2x^2-7x+6}+2)=0;$$
$$\therefore \sqrt{2x^2-7x+6}=0; \text{ or}$$
$$\sqrt{2x^2-7x+6}+2=0, \text{ which gives}$$

$2x^2-7x+6=0$; or $2x^2-7x+6=(-2)^2$; both of which are easily solved.

*Work* the following :—

24. The perimeter of a rectangle and one of the shorter sides together are 46 inches long; the area of the rectangle is $88\frac{1}{2}$ square inches; find the length of each side.

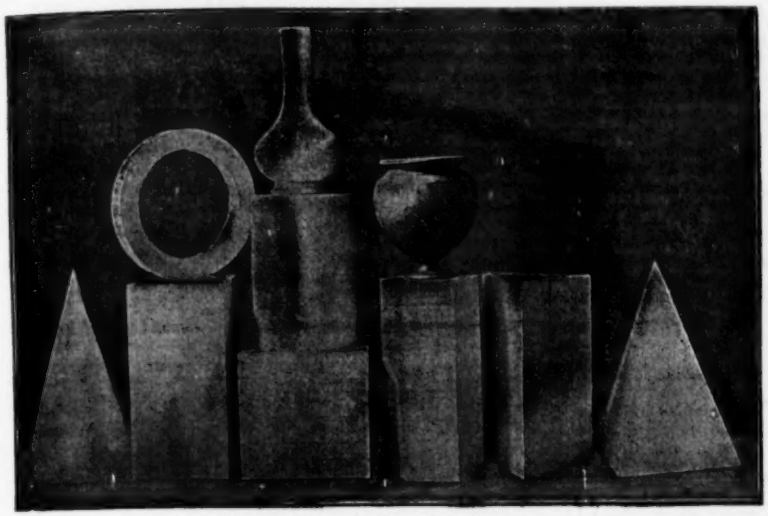
Ans. $11\frac{1}{2}$ inches; $7\frac{3}{4}$ inches.

25. A man has some money to give away, and certain men apply for a share; at first he thinks of giving 10s. apiece to each applicant except seven; on second thoughts, however, he divides the money that he would thus have given away into 15 equal parts, and gives one part to each applicant except three; he thereby saves a pound; how many applicants were there? Show that the question admits of two answers.

Ans. 12 or 13.

26. A rectangular field contains $1\frac{1}{2}$ acres; if it were 11 yards longer, and 7 yards narrower than it is, its area would be unaltered; find its length and breadth.

Ans. 110 yards; 77 yards.



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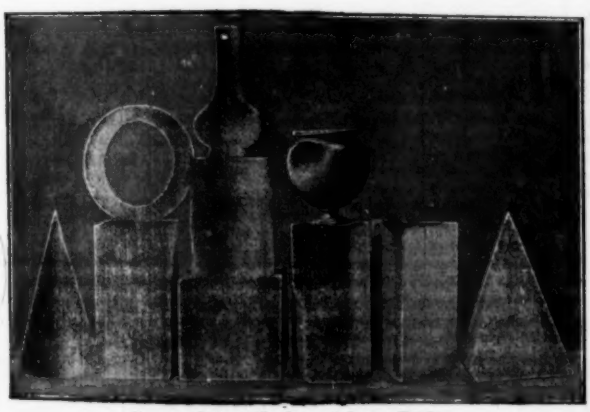

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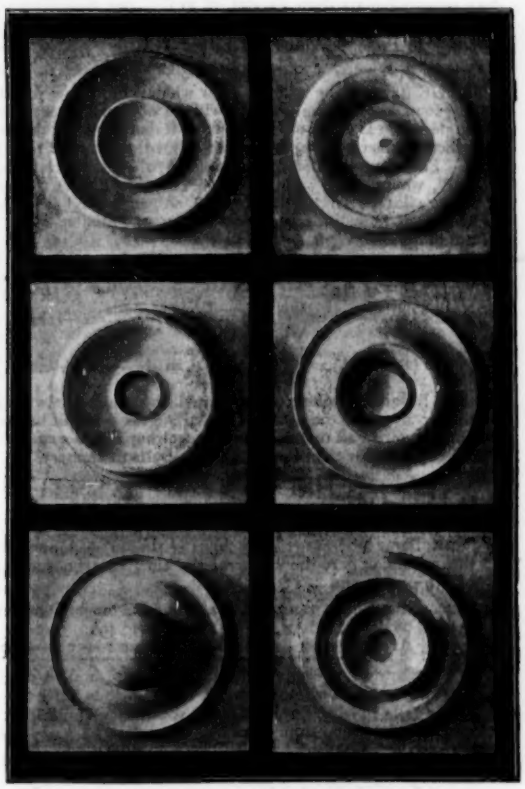

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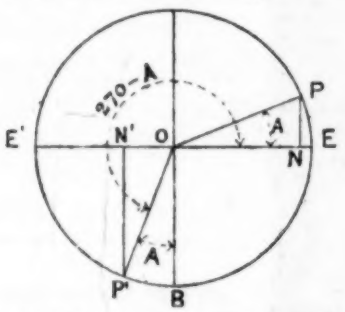
*Trigonometry.*

In Arts. 99–104 in H.S., or Arts. 117, 140, 141 in Lock's Trigonometry, appear some results of extreme importance, but we are anxious to impress on the student the fact that it is unnecessary to remember all these results. It is necessary, however, that he should remember that such results exist. They can be derived immediately from a figure. Let us take a general view of what is contained in these articles. In fig. 1 suppose a radius to revolve




from OE to OP ; draw PN perpendicular to E¹E. It will be clear that if we suppose the radius to continue to rotate once round, it will pass through certain positions, such that if we stop there and draw perpendiculars from its end on to E¹E, we shall obtain a set of triangles each equal to PON in every respect. The angles corresponding to these positions will be $90° - A$, $90° + A$, $180° - A$, $180° + A$, $270° - A$, $270° + A$, and $360° - A$, where A is the angle POE (taken to be acute). Now whatever angle we select out of this group, its sine, cosine, etc., will be obtained by considering a triangle which is equal to PON, hence it is clear that the trigonometrical ratios of these angles are related to those of the angle PON. For example, consider the angle $270° - A$, which is shown by EOP¹, where $P^1OB = A$. Draw $P^1N^1$, then $P^1ON^1$ is equal in all respects to the triangle PON ; but although $P^1N^1$ is the same *length* as ON, these lines are of *different sign*. Similarly $ON^1$ and PN are of *different sign*.

$$\text{Now } \sin(270° - A) = \frac{P^1N^1}{OP^1} = \frac{-ON}{OP} = -\frac{ON}{OP} = -\cos A,$$

$$\cos(270° - A) = \frac{ON^1}{OP^1} = \frac{-PN}{OP} = -\frac{PN}{OP} = -\sin A,$$

$$\tan(270° - A) = \frac{P^1N^1}{ON^1} = \frac{-ON}{-PN} = +\frac{ON}{PN} = +\tan A,$$

and so on for all the other angles, care being taken to always give the proper *signs* to the sides of the triangles. It will be better, therefore, to direct all one's efforts to acquiring the *general method* of proceeding rather than to commit the results to memory.

*Work out* Exs. XXII., H.S., or Exs. XXV., 1 to 10, and 17, 21, 24, 29, 31, in Lock.

Also the following :—

21. Show that $\cos(180° - A) = -\sin(90° + A)$, and write down from a figure the values of the sine, tangent, and secant of 150°, 240°, and −135°.

22. Given that $5 \tan 11° 19' = 1$, find the tangent and cotangent of 78° 41′, 168° 41′, 258° 41′, and 281° 19′.

Ans. 5 ; 0·2 : −0·2 ; −5 : 5 ; 0·2 : −5 ; −0·2.

23. Show in a diagram an angle of 300°, and in another diagram an angle of (90° − 300°), taking care to letter the diagrams so as to leave no doubt about your meaning. Repeat the diagrams, and show from them that $\cos 300° = \sin(90° - 300°)$ both in sign and magnitude.

We must now pass on to the subject of logarithms.

Let us state precisely what is necessary to be read.

The definition of a logarithm will be found in Art. 138, H.S., or Art. 192, Lock ; this must be carefully studied. It involves three things, the *number*, *base*, and *index*, the latter of which is the *logarithm*. With the manner in which the tables of logarithms are formed we have nothing to do ; but the student must grasp what is meant when it is said that the common logarithm of 1694·2 is 3·2289647, namely, that if we could raise the number 10 to the power 3·2289647 we should get 1694·2, 10 being selected as the *base*.

The three rules for working with logarithms are given in Arts. 147–150, H.S., or Art. 193 in Lock. The method of establishing these rules is an important matter, also the definitions of *mantissa* and *characteristic*. It must be noticed that a logarithm is never left in the form of a negative decimal. Should a logarithm turn out in an example to be, say, −·2684192, we must add 1 and subtract 1, thus, $1 - 2684192 - 1 = +\cdot7315808 - 1$, which is written as $\bar{1}\cdot7315808$, in which the mantissa is positive.

In working many of the examples in logarithms the method adopted is to make the required logarithms depend on one or more which are given. Thus 64 can be made to depend on 2, for $64 = 2^6$, and the rule for involution in logarithms tells us that $\log 64 = \log 2^6 = 6 \log 2$, which is known if log 2 is given. In the same way 1029 can be made to depend on 3 and 7, for $1029 = 3 \times 7 \times 7 \times 7$, therefore $\log 1029 = \log 3 + 3 \log 7$, and if these are given, we obtain log 1029. A decimal fraction must be first reduced to a vulgar fraction, then its logarithm is obtained by applying the rule for division.

*Work out* the following :—

24. Find the logarithms of 2000, $\frac{2}{10000}$, and $\frac{1}{256}$, if log 2 = ·30103.

Ans. $3\cdot30103$ ; $\bar{4}\cdot30103$ ; $\bar{3}\cdot59176$.

25. Given log 2 = ·30103, log 3 = ·477121, and log 7 = ·845098, find logarithms of ·005, 6·3, $\left(\frac{49}{216}\right)^{\frac{1}{3}}$.

Ans. $\bar{3}\cdot69897$ ; ·79934 ; $\bar{1}\cdot785247$.

*Geometry.*

*Read* the first *ten* propositions in Book III.

STAGE 3.

*Algebra.*

*Solution to Ex.* 7 (*January*).—

$a, b, c$ are in A.P. $\quad\therefore a + c = 2b$. (1)

$b, c, a$ ,, G.P. $\quad\therefore ab = c^2$. (2)

Are $c, a, b$ in H.P., that is, are $\frac{1}{c}, \frac{1}{a}, \frac{1}{b}$ in A.P., or is $\frac{1}{c} + \frac{1}{b} = \frac{2}{a}$? Simplify, then we have to prove that $ab + ac = 2bc$. This has to be done by using (1) and (2). Multiply (1) by $c$, then $ac + c^2 = 2bc$, which, by using (2), becomes $ac + ab = 2bc$.—Q.E.D.

*Solution to Ex.* 10.—Let the digits be $a$, $ar$, $ar^2$, then from the last two statements in the question we get $a + ar^2 = 2ar + 1$, and $a + ar = \frac{2}{3}(ar + ar^2)$ ; dividing the last by $a + ar$ (for this cannot be zero), we get $1 = \frac{2}{3}r$, or $r = \frac{3}{2}$.

Put this in first equation, and we get $a = 4$; hence digits are 4, 6, 9.

In this stage questions are often set on parts of the subject which are apparently not indicated in the syllabus ; from their very miscellaneous nature it would be difficult to include them. We now purpose to indicate a few types.

We have already alluded to the type of series in Art. 473, Tod., or Art. 60, H.K., namely, $a + (a + b)r + (a + 2b)r + \ldots\ldots$ in which the first factors in each term are in A.P., and the second factors in G.P. We sum this series by multiplying both sides by the common ratio of the G.P. For example, if we have to sum the following series to infinity, $1 + \frac{4}{3} + \frac{7}{3^2} + \frac{10}{3^3} + \ldots\ldots$ we multiply by $\frac{1}{3}$, thus :—

$$s = 1 + \frac{4}{3} + \frac{7}{3^2} + \frac{10}{3^3} + \ldots\ldots$$

$$\frac{s}{3} = \quad\frac{1}{3} + \frac{4}{3^2} + \frac{7}{3^3} + \ldots\ldots\text{; then subtracting,}$$

$$\frac{2}{3}s = 1 + \frac{3}{3} + \frac{3}{3^2} + \frac{3}{3^3} + \ldots\ldots$$

$$1 + 3\left(\frac{1}{3} + \frac{1}{3^2} + \frac{1}{3^3} + \ldots\ldots \text{ to infin.}\right)$$

$$= 1 + 3\left(\frac{\frac{1}{3}}{1 - \frac{1}{3}}\right) = \frac{5}{2}.$$

$$\therefore s = 3\tfrac{3}{4}.$$

On the same lines *work out* the following :—

12. Show that $\frac{3}{4}+\frac{4}{8}+\frac{5}{16}+\frac{6}{32}+$ ..... to infin. = 2.

13. Sum to $n$ terms $1 + 3x + 5x^2 + 7x^3 +$ .....

14. Write the $n$th term of $1 + 3x + 7x^2 + 13x^3 + 21x^4 +$ .....

Ans. (13). $\frac{1}{(1-x)^2}[1 + x - (2n + 1)\,x^n + (2n - 1)x^{n+1}]$; (14). $(n^2 - n + 1)x^{n-1}$.

In some series the $n$th term will split into two terms, and this gives the method of breaking up each term, thus :—

Sum $\frac{1}{1\cdot2}+\frac{1}{2\cdot3}+\frac{1}{3\cdot4}+$ ..... to $n$ terms. The $n$th term is $\frac{1}{n(n+1)}=\frac{1}{n}-\frac{1}{n+1}$, hence we get, by giving to $n$ the successive values 1, 2, 3, etc.,

$$\left(\frac{1}{1}-\frac{1}{2}\right)+\left(\frac{1}{2}-\frac{1}{3}\right)+\left(\frac{1}{3}-\frac{1}{4}\right)+\ldots\ldots\left(\frac{1}{n}-\frac{1}{n+1}\right),$$

in which all terms cancel except first and last, therefore $s = 1 - \frac{1}{n+1} = \frac{n}{n+1}$. Now this $= \frac{1}{1+\frac{1}{n}}$, which $= 1$ if $n$ is infinite.

15. Show that $\frac{1}{2^2}+\frac{1}{3^2}+\frac{1}{4^2}+$ ..... to infinity is less than 1.

(*Hint.*—Compare term for term with the series in example just worked.)

16. Sum to $n$ terms, and to infinity the series

$$\frac{1}{1}\cdot\frac{1}{4}+\frac{1}{4}\cdot\frac{1}{7}+\frac{1}{7}\cdot\frac{1}{10}+\ldots\ldots$$

Ans. $\frac{n}{3n+1}$; $\frac{1}{3}$.

*Read* Arts. 460, 461, Tod., or Arts. 68, 69, H.K., and work out the following :—

17. Find the sum to $n$ terms of the series whose $n$th term is $n(n + 2)$.

Ans. $(n + 1)(2n + 7)\frac{n}{6}$.

18. Write down the $n$th term of the series $1.2.3 + 2.3.4 + 3.4.5 +$ ....., break up the $n$th term, and sum the series to $n$ terms.

Ans. $n(n + 1)(n + 2)$; $\frac{n}{4}(n + 1)(n^2 + 13n + 10)$.

In some cases of algebraical expressions containing $x$ simply, it is possible to find the maximum and minimum values and to show that so long as $x$ is real, the value of the expression cannot lie between certain limits.

*See* Art. 345, Tod., or H.K., Art. 119, and *work out* Ex. 15, p. 196, Tod., or Ex. 3, p. 92, H.K.

*Example.*—Find the greatest value of the expression $21 + 4x - x^2$.

*Solution.*—Put $n = 21 + 4x - x^2$, and solve the quadratic ; we get $x = 2 \pm \sqrt{25 - n}$. If $x$ be real we must be able to extract the square root of $25 - n$, but this would be impossible if $n$ were greater than 25, hence the greatest value of $-x^2 + 4x + 21$ is 25. Or otherwise, $21 + 4x - x^2 = 21 + 4 - 4 + 4x - x^2 = 25 - (x - 2)^2$, which is clearly greatest when $(x - 2)^2$ is least, that is, when $x = 2$, the value of $21 + 4x - x^2$ then being 25.

### *Trigonometry.*

*Solution to Ex.* 16 (*January*).—

(Sin A — cos A)$\sqrt{2} = 1$. Square both sides, we get $\sin^2 A - 2 \sin A \cos A + \cos^2 A = \frac{1}{2}$; then, since $\sin^2 A + \cos^2 A = 1$ and $2 \sin A \cos A = \sin 2A$, we have $\sin 2A = \frac{1}{2}$. Therefore 2A equals any of the angles 30°, 150°, 390°, 510°, etc. ; that is, A = 15°, 75°, 195°, or 255° (angles less than 360°). Now the right-hand of the equation is positive, therefore the left-hand is positive, but if A = 15°, (sin A — cos A) is negative, for cos 15° is greater than sin 15°; hence we require to take the negative sign for $\sqrt{2}$. Similar treatment will show that if A = 255° we must also assume $\sqrt{2}$ to be negative, but positive when A = 75° or 195°.

*Ex.* 17. Unfortunately this was absurd as it was stated. The omission was that $a = 5$, $b = 4$. Cos C may now be found.

*Read* very carefully through Arts. 175 to 183 in Lock's Elem. Trig., or Tod., Chap. VII., or Loney, Arts. 110, 113, 114, 117, or Hamblin Smith, Arts. 133, 135.

*Work out* Lock, Exs. XLVI. 2, Exs. XLVII. 4, 8, or Tod, Chap. VII., Exs. 1, 2, 11, 12, or Loney, Exs. XVIII. 6, 26, or Hamblin Smith, Exs. XXXVII.

*Example.*—Calculate the numerical value of cotan 54° 45′. cot 157° 48′, having given

| | |
|---|---|
| L tan 22° 12′ = 9·6107586 | log 1·7317 = ·2384727 |
| L tan 35° 15′ = 9·8492536 | 1·7318 = ·2384977 |

*Solution.*—

$$\cot 54° 15'.\cot 157° 48' = \tan 35° 15'\,(-\cot 22° 12') = -\frac{\tan 35° 15'}{\tan 22° 12'}.$$

Let $x = \frac{\tan 35° 15'}{\tan 22° 12'}$

log $x$ = L tan 35° 15′ — 10 — (L tan 22° 12′ — 10)
= ·2384950,

which lies between the given logarithms ; hence $x$ may be easily found to be 1·7317892, and therefore the required value is — 1·7317892.

As a rule, in such examples we have to be ready to change an angle into its supplement or complement, making the necessary change in the ratio. If the trigonometrical expression consists of the sum or difference of two quantities, this must be arranged as a product or quotient before the logarithms are used.

*Work out* the following :—

18. Calculate the value of the expression sin 30° 39′ — sin 78° 49′, having given

| | |
|---|---|
| L sin 35° 16′ = 9·7614638 | log 2·3560 = ·3721753 |
| L sin 24° 5′ = 9·6107263 | log 2·3561 = ·3721937. |

Ans. ·4712161.

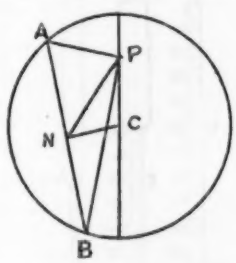
19. Find a value of $\theta$ satisfying the equation $\cos^3\theta = \cos 73° 6' - \cos 17° 42'$, having given

| | |
|---|---|
| L sin 45° 24′ = 9·8524959 | L sin 60° 38′ = 9·9402670 |
| L sin 27° 42′ = 9·6673054 | L sin 60° 39′ = 9·9403381. |

Ans. 29° 21′ 51·″5.

### *Geometry.*

*Solution to Ex* 5. (*January*).—Let AB be any chord subtending a right angle at P, N the mid-point. Draw the diameter through P. Examining for symmetry, it is quite evident that the diameter through P is a line of symmetry, for AB could be similarly placed on the right of PC. By taking a few chords, such as AB, and observing their middle points, we are led to *expect* that the locus is not a

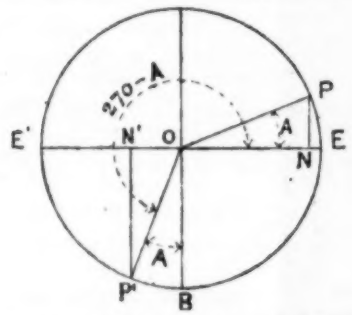



straight line, therefore try for a circle. P and C are fixed points, let us then try to prove that $NP^2 + NC^2 =$ constant, for if so the locus will be a circle. Making use of the fact that APB is a right angle, we get NP = AN, also since N is the middle point of AB, then $NC^2 = AC^2 - AN^2$, therefore $NP^2 + NC^2 = AC^2 =$ constant. The locus is therefore a circle, and we have shown (see December number) that the centre is midway between P and C, the fixed points.

*Solution to Ex.* 7.—Draw any two circles, centres A and B touching the fixed line at the fixed points F and H, In this case the circles might have been drawn below FH, hence FH is a line of symmetry. Also, since the smaller circle might have been drawn to touch at F, and the larger one at H, there will be symmetry about a line bisecting FH at right angles. All this leads us to *expect* a circle as the locus. Now F and H are fixed points, hence try to prove that $PF^2 + PH^2 =$ constant. Here will be some difficulty in getting expressions for PF and PH. Since, however, we have a

*Trigonometry.*

In Arts. 99–104 in H.S., or Arts. 117, 140, 141 in Lock's Trigonometry, appear some results of extreme importance, but we are anxious to impress on the student the fact that it is unnecessary to remember all these results. It is necessary, however, that he should remember that such results exist. They can be derived immediately from a figure. Let us take a general view of what is contained in these articles. In fig. 1 suppose a radius to revolve




from OE to OP; draw PN perpendicular to E¹E. It will be clear that if we suppose the radius to continue to rotate once round, it will pass through certain positions, such that if we stop there and draw perpendiculars from its end on to E¹E, we shall obtain a set of triangles each equal to PON in every respect. The angles corresponding to these positions will be $90° - A$, $90° + A$, $180° - A$, $180° + A$, $270° - A$, $270° + A$, and $360° - A$, where A is the angle POE (taken to be acute). Now whatever angle we select out of this group, its sine, cosine, etc., will be obtained by considering a triangle which is equal to PON, hence it is clear that the trigonometrical ratios of these angles are related to those of the angle PON. For example, consider the angle $270° - A$, which is shown by EOP¹, where $P^1OB = A$. Draw $P^1N^1$, then $P^1ON^1$ is equal in all respects to the triangle PON; but although $P^1N^1$ is the same *length* as ON, these lines are of *different sign*. Similarly $ON^1$ and PN are of *different sign*.

$$\text{Now } \sin(270° - A) = \frac{P^1N^1}{OP^1} = \frac{-ON}{OP} = -\frac{ON}{OP} = -\cos A,$$

$$\cos(270° - A) = \frac{ON^1}{OP^1} = \frac{-PN}{OP} = -\frac{PN}{OP} = -\sin A,$$

$$\tan(270° - A) = \frac{P^1N^1}{ON^1} = \frac{-ON}{-PN} = +\frac{ON}{PN} = +\tan A,$$

and so on for all the other angles, care being taken to always give the proper *signs* to the sides of the triangles. It will be better, therefore, to direct all one's efforts to acquiring the *general method* of proceeding rather than to commit the results to memory.

*Work out* Exs. XXII., H.S., or Exs. XXV., 1 to 10, and 17, 21, 24, 29, 31, in Lock.

Also the following :—

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We must now pass on to the subject of logarithms.

Let us state precisely what is necessary to be read.

The definition of a logarithm will be found in Art. 138, H.S., or Art. 192, Lock; this must be carefully studied. It involves three things, the *number*, *base*, and *index*, the latter of which is the *logarithm*. With the manner in which the tables of logarithms are formed we have nothing to do; but the student must grasp what is meant when it is said that the common logarithm of 1694·2 is 3·2289647, namely, that if we could raise the number 10 to the power 3·2289647 we should get 1694·2, 10 being selected as the *base*.

The three rules for working with logarithms are given in Arts. 147–150, H.S., or Art. 193 in Lock. The method of establishing these rules is an important matter, also the definitions of *mantissa* and *characteristic*. It must be noticed that a logarithm is never left in the form of a negative decimal. Should a logarithm turn out in an example to be, say, −·2684192, we must add 1 and subtract 1, thus, $1 - 2684192 - 1 = +\cdot7315808 - 1$, which is written as $\bar{1}\cdot7315808$, in which the mantissa is positive.

In working many of the examples in logarithms the method adopted is to make the required logarithms depend on one or more which are given. Thus 64 can be made to depend on 2, for $64 = 2^6$, and the rule for involution in logarithms tells us that $\log 64 = \log 2^6 = 6 \log 2$, which is known if log 2 is given. In the same way 1029 can be made to depend on 3 and 7, for $1029 = 3 \times 7 \times 7 \times 7$, therefore $\log 1029 = \log 3 + 3 \log 7$, and if these are given, we obtain log 1029. A decimal fraction must be first reduced to a vulgar fraction, then its logarithm is obtained by applying the rule for division.

*Work out* the following :—

24. Find the logarithms of 2000, $\frac{2}{10000}$, and $\frac{1}{256}$, if log 2 = ·30103. Ans. 3·30103 ; $\bar{4}$·30103 ; $\bar{3}$·59176.

25. Given log 2 = ·30103, log 3 = ·477121, and log 7 = ·845098, find logarithms of ·005, 6·3, $\left(\frac{49}{216}\right)^{\frac{1}{3}}$.

Ans. $\bar{3}$·69897 ; ·79934 ; $\bar{1}$·785247.

*Geometry.*

*Read* the first *ten* propositions in Book III.

STAGE 3.

*Algebra.*

*Solution to Ex.* 7 (*January*).—

$a, b, c$ are in A.P. $\quad \therefore a + c = 2b$. (1)

$b, c, a$ ,, G.P. $\quad \therefore ab = c^2$. (2)

Are $c, a, b$ in H.P., that is, are $\frac{1}{c}, \frac{1}{a}, \frac{1}{b}$ in A.P., or is $\frac{1}{c} + \frac{1}{b} = \frac{2}{a}$? Simplify, then we have to prove that $ab + ac = 2bc$. This has to be done by using (1) and (2). Multiply (1) by $c$, then $ac + c^2 = 2bc$, which, by using (2), becomes $ac + ab = 2bc$.—Q.E.D.

*Solution to Ex.* 10.—Let the digits be $a$, $ar$, $ar^2$, then from the last two statements in the question we get $a + ar^2 = 2ar + 1$, and $a + ar = \frac{2}{3}(ar + ar^2)$; dividing the last by $a + ar$ (for this cannot be zero), we get $1 = \frac{2}{3}r$, or $r = \frac{3}{2}$.

Put this in first equation, and we get $a = 4$; hence digits are 4, 6, 9.

In this stage questions are often set on parts of the subject which are apparently not indicated in the syllabus; from their very miscellaneous nature it would be difficult to include them. We now purpose to indicate a few types.

We have already alluded to the type of series in Art. 473, Tod., or Art. 60, H.K., namely, $a + (a + b)r + (a + 2b)r + \ldots\ldots$ in which the first factors in each term are in A.P., and the second factors in G.P. We sum this series by multiplying both sides by the common ratio of the G.P. For example, if we have to sum the following series to infinity, $1 + \frac{4}{3} + \frac{7}{3^2} + \frac{10}{3^3} + \ldots\ldots$ we multiply by $\frac{1}{3}$, thus :—

$$s = 1 + \frac{4}{3} + \frac{7}{3^2} + \frac{10}{3^3} + \ldots\ldots$$

$$\frac{s}{3} = \quad \frac{1}{3} + \frac{4}{3^2} + \frac{7}{3^3} + \ldots\ldots; \text{ then subtracting,}$$

$$\frac{2}{3}s = 1 + \frac{3}{3} + \frac{3}{3^2} + \frac{3}{3^3} + \ldots\ldots$$

$$1 + 3\left(\frac{1}{3} + \frac{1}{3^2} + \frac{1}{3^3} + \ldots\ldots \text{ to infin.}\right)$$

$$\therefore \quad = 1 + 3\left(\frac{\frac{1}{3}}{1 - \frac{1}{3}}\right) = \frac{5}{2}.$$

$$\therefore s = 3\tfrac{3}{4}.$$

On the same lines *work out* the following :—

12. Show that $\frac{3}{4}+\frac{4}{8}+\frac{5}{16}+\frac{6}{32}+$ ..... to infin. $= 2$.

13. Sum to $n$ terms $1 + 3x + 5x^2 + 7x^3 +$ .....

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Ans. (13). $\frac{1}{(1-x)^2}[1 + x - (2n + 1)x^n + (2n - 1)x^{n+1}]$; (14). $(n^2 - n + 1)x^{n-1}$.

In some series the $n$th term will split into two terms, and this gives the method of breaking up each term, thus :—

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$$\left(\frac{1}{1}-\frac{1}{2}\right)+\left(\frac{1}{2}-\frac{1}{3}\right)+\left(\frac{1}{3}-\frac{1}{4}\right)+\text{.....}\left(\frac{1}{n}-\frac{1}{n+1}\right),$$

in which all terms cancel except first and last, therefore $s = 1 - \frac{1}{n+1} = \frac{n}{n+1}$. Now this $= \frac{1}{1+\frac{1}{n}}$, which $= 1$ if $n$ is infinite.

15. Show that $\frac{1}{2^2}+\frac{1}{3^2}+\frac{1}{4^2}+$ ..... to infinity is less than 1.

(*Hint.*—Compare term for term with the series in example just worked.)

16. Sum to $n$ terms, and to infinity the series

$$\frac{1}{1}\cdot\frac{1}{4}+\frac{1}{4}\cdot\frac{1}{7}+\frac{1}{7}\cdot\frac{1}{10}+\text{.....}$$

Ans. $\frac{n}{3n+1}$; $\frac{1}{3}$.

*Read* Arts. 460, 461, Tod., or Arts. 68, 69, H.K., and work out the following :—

17. Find the sum to $n$ terms of the series whose $n$th term is $n(n + 2)$.

Ans. $(n + 1)(2n + 7)\frac{n}{6}$.

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Ans. $n(n + 1)(n + 2)$; $\frac{n}{4}(n + 1)(n^2 + 13n + 10)$.

In some cases of algebraical expressions containing $x$ simply, it is possible to find the maximum and minimum values and to show that so long as $x$ is real, the value of the expression cannot lie between certain limits.

*See* Art. 345, Tod., or H.K., Art. 119, and *work out* Ex. 15, p. 196, Tod., or Ex. 3, p. 92, H.K.

*Example.*—Find the greatest value of the expression $21 + 4x - x^2$.

*Solution.*—Put $n = 21 + 4x - x^2$, and solve the quadratic ; we get $x = 2 \pm \sqrt{25 - n}$. If $x$ be real we must be able to extract the square root of $25 - n$, but this would be impossible if $n$ were greater than 25, hence the greatest value of $-x^2 + 4x + 21$ is 25. Or otherwise, $21 + 4x - x^2 = 21 + 4 - 4 + 4x - x^2 = 25 - (x - 2)^2$, which is clearly greatest when $(x - 2)^2$ is least, that is, when $x = 2$, the value of $21 + 4x - x^2$ then being 25.

*Trigonometry.*

*Solution to Ex.* 16 (*January*).—

(Sin A — cos A)$\sqrt{2} = 1$. Square both sides, we get $\sin^2 A - 2 \sin A \cos A + \cos^2 A = \frac{1}{2}$; then, since $\sin^2 A + \cos^2 A = 1$ and $2 \sin A \cos A = \sin 2A$, we have $\sin 2A = \frac{1}{2}$. Therefore 2A equals any of the angles 30°, 150°, 390°, 510°, etc. ; that is, A = 15°, 75°, 195°, or 255° (angles less than 360°). Now the right-hand of the equation is positive, therefore the left-hand is positive, but if A = 15°, (sin A — cos A) is negative, for cos 15° is greater than sin 15°; hence we require to take the negative sign for $\sqrt{2}$. Similar treatment will show that if A = 255° we must also assume $\sqrt{2}$ to be negative, but positive when A = 75° or 195°.

*Ex.* 17. Unfortunately this was absurd as it was stated. The omission was that $a = 5$, $b = 4$. Cos C may now be found.

*Read* very carefully through Arts. 175 to 183 in Lock's Elem. Trig., or Tod., Chap. VII., or Loney, Arts. 110, 113, 114, 117, or Hamblin Smith, Arts. 133, 135.

*Work out* Lock, Exs. XLVI. 2, Exs. XLVII. 4, 8, or Tod, Chap. VII., Exs. 1, 2, 11, 12, or Loney, Exs. XVIII. 6, 26, or Hamblin Smith, Exs. XXXVII.

*Example.*—Calculate the numerical value of cotan 54° 45′. cot 157° 48′, having given

| | |
|---|---|
| L tan 22° 12′ = 9·6107586 | log 1·7317 = ·2384727 |
| L tan 35° 15′ = 9·8492536 | 1·7318 = ·2384977 |

*Solution.*—

$$\cot 54° 15'.\cot 157° 48' = \tan 35° 15' (-\cot 22° 12') = -\frac{\tan 35° 15'}{\tan 22° 12'}.$$

Let $x = \frac{\tan 35° 15'}{\tan 22° 12'}$

$\log x$ = L tan 35° 15′ — 10 — (L tan 22° 12′ — 10)
= ·2384950,

which lies between the given logarithms ; hence $x$ may be easily found to be 1·7317892, and therefore the required value is — 1·7317892.

As a rule, in such examples we have to be ready to change an angle into its supplement or complement, making the necessary change in the ratio. If the trigonometrical expression consists of the sum or difference of two quantities, this must be arranged as a product or quotient before the logarithms are used.

*Work out* the following :—

18. Calculate the value of the expression sin 30° 39′ — sin 78° 49′, having given

| | |
|---|---|
| L sin 35° 16′ = 9·7614638 | log 2·3560 = ·3721753 |
| L sin 24° 5′ = 9·6107263 | log 2·3561 = ·3721937. |

Ans. ·4712161.

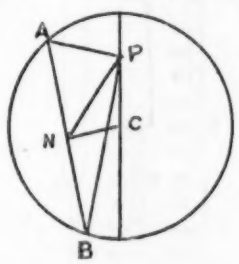
19. Find a value of $\theta$ satisfying the equation $\cos^3\theta = \cos 73° 6' - \cos 17° 42'$, having given

| | |
|---|---|
| L sin 45° 24′ = 9·8524959 | L sin 60° 38′ = 9·9402670 |
| L sin 27° 42′ = 9·6673054 | L sin 60° 39′ = 9·9403381. |

Ans. 29° 21′ 51″·5.

*Geometry.*

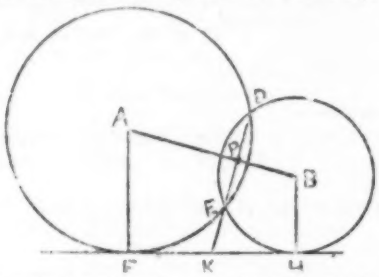
*Solution to Ex* 5. (*January*).—Let AB be any chord subtending a right angle at P, N the mid-point. Draw the diameter through P. Examining for symmetry, it is quite evident that the diameter through P is a line of symmetry, for AB could be similarly placed on the right of PC. By taking a few chords, such as AB, and observing their middle points, we are led to *expect* that the locus is not a




straight line, therefore try for a circle. P and C are fixed points, let us then try to prove that $NP^2 + NC^2 =$ constant, for if so the locus will be a circle. Making use of the fact that APB is a right angle, we get NP = AN, also since N is the middle point of AB, then $NC^2 = AC^2 - AN^2$, therefore $NP^2 + NC^2 = AC^2 =$ constant. The locus is therefore a circle, and we have shown (see December number) that the centre is midway between P and C, the fixed points.

*Solution to Ex.* 7.—Draw any two circles, centres A and B touching the fixed line at the fixed points F and H. In this case the circles might have been drawn below FH, hence FH is a line of symmetry. Also, since the smaller circle might have been drawn to touch at F, and the larger one at H, there will be symmetry about a line bisecting FH at right angles. All this leads us to *expect* a circle as the locus. Now F and H are fixed points, hence try to prove that $PF^2 + PH^2 =$ constant. Here will be some difficulty in getting expressions for PF and PH. Since, however, we have a

common tangent and chord occurring, we must make use of them. Thus on producing DE to meet FH at K we get $KF^2$ and $KH^2$ each equal to the rectangle KE.KD; hence K is the mid-point of FH.




We therefore have FK constant and KE.KD = $KF^2$, and introducing the constant length DE this becomes

$$(PK - \tfrac{1}{2}DE)(PK + \tfrac{1}{2}DE) = KF^2.$$

$$PK^2 - \tfrac{1}{4}DE^2 = KF^2$$

$$PK^2 = KF^2 + \tfrac{1}{4}DE^2 = \text{const.}$$

Hence P moves on a circle with K as centre.

*Work the following riders :—*

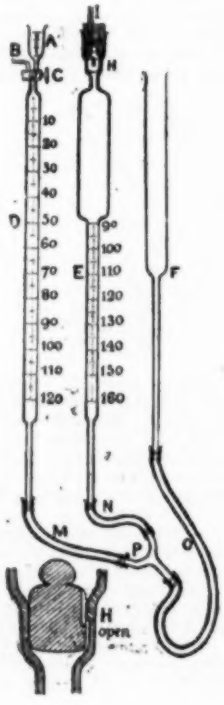
8. AB is a given straight line, and P, Q are two given points on the same side of it; find the point in AB at which the line joining P and Q subtends the greatest angle.

9. A, B, C are three points in order in a straight line, such that AB equals one-half of BC; with B as centre and radius equal to half of AB describe a circle; take P any point in the circumference, join AP and produce it to Q, making PQ equal to AP; join QB, QC; show that BQC is a right angle.

## CHEMISTRY NOTES.

BY W. TATE, A.R.C.S., F.C.S.

GENERAL NOTES.—The gas-volumeter is a convenient instrument for the measurement of volumes of gases, as it may be used in such a way that no reductions require to be made for temperature, pressure, or moisture.




It consists essentially of three parts—(1) the *gas burette* D graduated in cubic centimetres (each c.c. being subdivided into fifths) and supplied with a two-way tap C, by means of which communication can be made with the graduated cup A or with the tube B. (2) The *standard atmosphere tube* E graduated on its narrow portion in the same way as D, but only indicating from about 90 to 140 c.c. This tube is supplied, in the best type of apparatus, with a gas-tight stopper at H, consisting of a carefully ground glass stopper, which has a small groove running from its upper surface half way down the stopper, fitted into the narrow part of a cup; in the wall of the cup a groove is cut from below to just such a height as will allow the stopper groove to communicate with the neck groove in one position of the stopper; the cup is filled up with mercury, which is kept in position by a cork I, through which protrudes a small open tube, allowing for expansion of the mercury. (3) The *levelling tube* F. The tubes D, E, and F are connected by thick-walled caoutchouc tubing, MNO, through a stout glass Y-piece P. Finally, the whole is supported in a suitable stand with adjustable clamps.

To use the instrument, we first set the standard atmosphere in E. If the stopper H remains gas-tight, this operation is done once for all. Mercury is poured into F until the lower part of each tube is occupied, care being taken by suitably working the flexible tubing that no air bubbles remain below the mercury surface. Sufficient water is then introduced through H to moisten the sides of E without collecting on the mercury surface. The temperature and pressure of the atmosphere having been carefully taken, the volume which 100 c.c. of dry air at 0°C. and 760 mm. pressure would occupy at the ascertained temperature, $t$°C., and pressure, P mm., and in the moist state, is calculated.

The required volume

$$= \frac{100 \times (273 + t) \times 760}{273 \times (P - p)} \text{ c.cs.},$$

where $p$ is the vapour pressure of water at $t$°C. This volume of air is admitted through H, time allowed for it to become thoroughly moist, the mercury level is then accurately adjusted to the mark on E indicating the required volume (by raising or lowering the levelling tube F), and the stopper turned off, covered with mercury, and the cup corked. If now the level of the mercury be brought to the mark 100 on E by raising F, the standard atmosphere tube will contain moist air at the temperature of the time of experiment and at some pressure $(P + x)$ mm. where P is the height of the barometer and $x$ is the difference in level between the mercury surface in F and that in E, yet the indicated volume is that (100 c.c.) which would be occupied by the same quantity of air when dry and at 0°C. and 760 mm. pressure. Whatever the actual pressure and temperature may be, the volume is *mechanically reduced* to that which would be occupied *under standard conditions*. The extra pressure $x$ mm. compensates for the difference in temperature and hygrometric state.

It is evident that, if a quantity of moist gas be contained in the burette D and the level of mercury is adjusted in D to exactly the same height as E (by raising or lowering D), and the level in E is *at the same time* at 100, we shall be able to read off the volume on D which would be occupied by the gas under standard conditions and dry. This follows because the gases in D and E are both subjected to the *same* pressure and temperature (and are in the same hygrometric state in consequence of being at the same temperature), and are therefore in the same state, but the gas in E, when the mercury is at 100, occupies standard reduced volume, hence the gas in D now occupies its reduced volume.

The same relations hold if D communicates through B with any closed vessel; the whole quantity of gas in vessel, connections, and burette is reduced to its volume under standard conditions when the levels in D and E are the same and the mercury in E is at 100. Any difference of volume in this system between certain limits (the capacity of the burette defines these limits) can thus be readily ascertained in reduced volume.

The instrument may be used for any purpose in which the measurement of volumes of gases is the essential step, for instance—(*a*) A solution of potassium permanganate may be standardized by taking a measured quantity of the permanganate solution in a small tube, and placing this in a flask containing a quantity of hydroxyl strongly acidified with sulphuric acid (the hydroxyl may be of any strength provided an excess be taken, indicated by the comple decolourization of the permanganate), the volume indicated on D, after connection with the flask and allowing to assume a constant temperature, is noted and the permanganate brought into contact with the acidified hydroxyl by inclining the tube and flask. Oxygen is liberated in accordance with the equation $K_2Mn_2O_8 + 4H_2SO_4 + 5H_2O_2 = 2KHSO_4 + 2MnSO_4 + 8H_2O + 5O_2$. After the reaction, the whole is allowed to cool down to the surrounding temperature and the volume again read off from D. The difference of the two readings gives the volume of oxygen liberated. From the equation given

above, we see that half this oxygen is derived from the hydroxyl and half from the permanganate; the oxidizing power of the permanganate solution may therefore be readily calculated. (*b*) The specific gravity of a soluble powder may be ascertained by using the instrument as a volumenometer. A flask is connected with B and the tap C opened to the air through A. The level of mercury is then brought to any desired point on D (say 50) by means of F. The tap C is turned through a right angle and connects D with B. The levels in D corresponding to two selected levels in E (say 100 and 110) are then read off. Then

$$\frac{\text{Difference of vols. on D}}{\text{Difference of vols. on E}} = \frac{\text{1st vol. of D and connections}}{\text{1st vol. of E}},$$

hence the total volume of flask, connections, and D down to 1st reading is known. The flask is now weighed, a quantity of powder added thereto, again weighed, connected with D, and the same operations passed through as before. The difference in weights gives the weight of powder taken, the difference in volumes of the system is the volume of the same, and we have the density at once = *Weight ÷ Volume. (*c*) That air is a mixture of gases may be proved by (1) analysing air, and (2) extracting the dissolved air from a quantity of air-saturated water and analysing the air extracted. The proportions of nitrogen and oxygen are found to be very different in the two cases; it follows that air must be a mixture of these two gases which dissolve differently. It is sufficient if we determine the proportion of oxygen in each case. The volume of mixed gases is measured in the burette D and then passed into a Hempel's pipette containing alkaline pyrogallate; after absorption of the oxygen the residual gas is brought back into D and measured; this operation is repeated until there is no further diminution of volume. The final loss of volume corresponds to the oxygen present in the volume of gas taken. For details concerning the extraction of gases from water see Sutton's 'Volumetric Analysis' (5th edition), p. 481.

Some interesting information concerning the new element Argon (symbol A) may be looked for in the principal papers about February 1st, as a communication is to be made to the Royal Society on the 31st inst. (January) concerning this substance.

According to a paper published by Moissan in the *Comptes Rendus*, all forms of carbon are converted into graphite at the high temperatures obtained with his powerful electric furnace. At ordinary pressures or below he has succeeded in volatilizing carbon, which is deposited in the solid state as graphite, showing no traces of an intermediate liquid state. When graphite has been produced under great pressures, as in the interior of masses of cast-iron, traces of fusion are observed. It may be that carbon could be liquefied under sufficiently high pressures. The properties of graphite vary to some extent with the temperature at which it has been produced. The higher this temperature, the greater is its resisting power towards chemical reagents.

PRACTICAL NOTES.—The solubility of hydrates (better termed hydroxides), etc., precipitated by ammonia varies widely. In Group I., silver salts yield an oxide readily dissolved in excess, lead gives insoluble basic salts, and mercury yields insoluble ammonium derivatives in which a part of the H of the ($NH_4$) group is replaced by ($Hg_2$)″, *e.g.* $NH_2Hg_2Cl$ derived from $NH_4Cl$. No hydrates are precipitated in this group. In Group II., Hg″ salts yield insoluble ammonium derivatives of the type $NH_2Hg''Cl$, bismuth gives a hydrate insoluble in excess, copper and cadmium yield precipitates soluble in excess of ammonia, stannous compounds yield an insoluble hydrate, the corresponding compound from stannic salts is slightly soluble in excess of ammonia and is not precipitated in presence of tartaric acid, antimony salts yield a slightly soluble precipitate; the reaction is only of importance in this group owing to its use in separating bismuth from copper and cadmium. In Groups III., IV., and V. the ammonia reaction is of first importance. All hydrates other than those from Fe, Al, Cr salts are prevented from being precipitated by the presence of ammonium chloride owing to the formation of double salts of a comparatively stable character after the type $MgCl_2.2AmCl$. The hydrate of iron is quite insoluble in excess of AmOH, provided the iron be in the ferric state, hence the imperative necessity for oxidation of ferrous salts, by boiling with $HNO_3$ or bromine or chlorine water, before separation with ammonia. Chromic hydrate is somewhat soluble in excess of reagent, and aluminic hydrate is much more soluble in ammonia. In these cases excess of reagent must be avoided or boiled off; where permissible, the addition of a little ammonium sulphide much facilitates the separation of the hydrate. Zinc, nickel, and cobalt hydrates are readily soluble in excess of ammonia. Manganous hydrate is nearly insoluble in ammonia or ammonium carbonate, but dissolves readily in AmCl; the solution rapidly oxidizes in contact with air, and manganic hydrates are produced insoluble even in AmCl, hence the need to redissolve and reprecipitate the iron sub-group when manganese is present. It is impossible to completely separate Fe, Al, and Cr from manganese by means of ammonia. It is of importance to note that unless sufficient AmCl be added to convert the whole of a magnesium salt into the soluble double salt (Mg.Am), half of the remainder will be precipitated on the addition of AmOH as the very insoluble magnesium hydrate, thus—

$$2MgCl_2 + 2AmOH = MgO_2H_2 + 2AmCl.MgCl_2 \text{ (not precipitated by AmOH).}$$

For the *detection* of the halogen acids in presence of each other, the following method can be recommended, particularly if only a small proportion of a chloride be present together with much iodide or bromide.

If the material is not soluble in dilute sulphuric acid, add a few pieces of pure granulated zinc and some warm dilute sulphuric acid and allow to stand for about 10 minutes. Drain off the solution and boil the residue with pure sodium carbonate and a little water, and filter after continued boiling. Add the solutions.

The treatment with zinc will decompose silver salts; all others can be decomposed by the $Na_2CO_3$ treatment.

To a small portion of the solution acidified with $H_2SO_4$ add two drops of chlorine water and a half c.c. of carbon bisulphide, and shake—a characteristic violet colouration of the $CS_2$ indicates iodine, and therefore hydriodic acid.

Add chlorine water to the same test, little by little, until the violet colouration disappears. If a clear orange-brown colouration remains, bromine is present and hence hydrobromic acid.

To test for Cl in presence of Br or I, take a small portion of the solution in a porcelain basin and add dilute sulphuric acid (1 to 5) in large quantity. Add dilute solution of permanganate of potassium drop by drop, while boiling and stirring, until a slight permanent rose tint is obtained. Test this solution in the ordinary way with $HNO_3$ and $AgNO_3$. Cl is present if a *curdy* white precipitate is obtained, very soluble in AmOH.

We may consider that, in presence of the large excess of sulphuric acid, HCl, HBr, and HI are in solution. Of these, HI is first oxidized by the permanganate as follows,—$K_2Mn_2O_8 + 4H_2SO_4 + 10HI = 2KHSO_4 + 2MnSO_4 + 8H_2O + 5I_2$—and the iodine volatilizes; the HBr is then destroyed in the same manner. Finally, HCl begins to be attacked, but very slowly as compared with the other halogen acids.

So soon as the rapid decolourization of the $K_2Mn_2O_8$ ceases, the Cl is tested for, as all the Br and I have been expelled at this point. The method is not available for quantitative separations, because the reactions are not strictly consecutive; about ½ to 1 per cent. of the chlorine actually present goes off with the other halogens.

REFERENCES.—The more advanced students would do well to read the article in Watt's 'Dictionary of Chemistry,' Vol. I., pp. 336 to 361, treating of Atomic and Molecular Weights. A very useful short account of the use of the generalization known as the Periodic Law is included in the article, pp. 351–352.

In the same volume, 'Aggregation, States of,' is well worth the earnest attention of all serious workers.

Read in the January, 1895, number of the Journal of the Chemical Society:—Abstracts—Electrolysis of Copper Sulphate, by A. Chassy, p. 4. Polymerization of Liquid Molecules, by P. A. Guye, p. 8. Ratio of the Atomic Weights of Hydrogen and Oxygen, by L. Meyer and K. Seubert, p. 9. Nitrous Anhydride, by G. Lunge and G. Porschnew, p. 12. Nitrogen Compounds of Manganese, by O. Prelinger, p. 16.

NOTES ON QUESTIONS.—*Adv.* (10), Newth, p. 487. The amount of caustic soda obtainable from 500 grains of washing-soda crystals if the whole were converted without waste would be

$$\frac{500 \times 80}{286} = 139{\cdot}8 \text{ grams,}$$

for from $Na_2CO_3.10H_2O$ we obtain 2NaOH, and the sums of the atomic weights are here respectively 286 and 80. *Adv.* (11). See Newth, p. 614. *Adv. Pract.* (5). See above. *Adv. Pract.* (6). A short synopsis of impurities in common reagents and methods for examination for each case will shortly be given. *Hon.* (10) (*a*) Cupric salts react with hydriodic acid as follows,—$2CuSO_4 + 4HI = Cu_2I_2 + I_2 + 2H_2SO_4$—the atomic weight of iodine being set free by the action of the atomic weight of copper. About 6·4 grams of pure copper are weighed carefully and transferred to a conical flask with a small funnel in the neck. A sufficient quantity of nitric acid (1 : 1) is added and the copper dissolved with gentle heat. The solution is transferred to a porcelain dish and evaporated with sulphuric acid (just more than sufficient to form sulphate), first on the water bath and then over a naked flame, with great care, until anhydrous $CuSO_4$ separates. By this treatment $HNO_3$ is expelled. The salt is redissolved, transferred to a litre flask, together with an excess of sodium acetate and a little acetic acid, and made up to

* More correctly *Mass.*

the mark with distilled water. Aliquot parts are taken out with a pipette, added to a solution of pure potassium iodide, and the liberated iodine titrated by the thiosulphate solution. From the quantity of Cu taken and the c.c. of 'thio' used, the value of the latter in grams of iodine per c.c. can be readily calculated.

(*b*) Potassium permanganate similarly liberates iodine, thus:— $K_2Mn_2O_8 + 14H_2SO_4 + 10KI = 12KHSO_4 + 2MnSO_4 + 8H_2O + 5I_2$. A weighed quantity of permanganate is made up to one litre, portions added to excess of KI dissolved in pure dilute sulphuric acid, and titrated as above.

(*c*) The iodine is resublimed, dried over sulphuric acid, a quantity weighed into a litre flask, dissolved in pure potassium iodide solution, made up to one litre, and portions titrated as in (*a*).

The reaction between thiosulphate and iodine may be represented as a condensation, thus—$2Na_2S_2O_3 + I_2 = 2NaI + Na_2S_4O_6$.

EXERCISES.

*Advanced Stage.*—(12) Give a rough plan of a plant for the production of sulphuric acid on a large scale, and give some account of the use of each part of the works represented. (13) What is understood by the term 'atmolysis'? Give any instances of the use of methods depending on atmolysis for the distinction between gaseous mixtures and compounds. Describe briefly one such method.

*Advanced Practical.*—(7) Name the impurities met with in dry sodium carbonate. How would you detect each of these impurities? Using the fusion method of examination for aluminium in presence of iron, how could you avoid using this carbonate? Explain the reactions involved. (8) How would you proceed to detect a nitrate in presence of a relatively large proportion of a bromide?

*Honours.*—(11) Describe the method you would adopt for the estimation of alkalies in a felspar. (12) Give a short account of Mallett's researches on the atomic weight of aluminium.

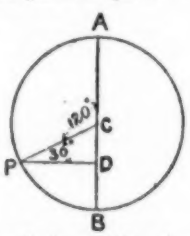
## SOLUTIONS TO QUESTIONS IN THEORETICAL MECHANICS.

BY F. CASTLE, M.I.M.E.

*Continued from p.* 386.

22. What is meant by the pressure of a fluid at a point? A is the highest point of the vertical diameter of a sphere whose centre is C; the sphere is hollow and full of water; P is a point on the inner surface such that PCA is 120°; find the horizontal and vertical components of the pressure at P. Find also numerical values for the components in pounds per square foot, the radius being 3 ft. (N.B.—Assume that a cubic inch of water weighs 252 grains.) (20)

The pressure at any point in any direction is an expression to denote the average pressure per unit of area on a plane surface, imagined as containing the point, and perpendicular to the direction in question, when the area of that surface is made indefinitely small; or, is the pressure on unit area at a depth equal to the depth of the point.




Draw PD perpendicular to AB, and meeting AB at D; then AD is the depth of point P and $AD = \frac{3}{2}r$. Hence pressure at $P = 1 \times \frac{3}{2}r \times w = \frac{3r \times w}{2}$, where $w$ = weight of unit vol. of the liquid.

Horizontal component of pressure at P

$$= \frac{3r}{2} \times w \times \cos CPD$$

$$= \frac{3r}{2} \times w \times \cos 30°$$

$$= \frac{3\sqrt{3}}{4} \times r \times w.$$

Vertical component of pressure at P

$$= \frac{3r}{2} \times w \times \sin CPD$$

$$= \frac{3r}{2} \times w \times \sin 30°$$

$$= \frac{3rw}{4}.$$

$\therefore$ Horizontal component

$$= \frac{3 \times 3 \times 252 \times 1728 \times \sqrt{3}}{4} \text{ grains}$$

$$= \frac{9 \times 252 \times 1728 \times \sqrt{3}}{4 \times 16 \times 20 \times 24} \text{ lbs.}$$

$$= 220{\cdot}96 \text{ lbs.}$$

Vertical component

$$= \frac{3 \times 3 \times 252 \times 1728}{4 \times 16 \times 20 \times 24} \text{ lbs.}$$

$$= 127{\cdot}57 \text{ lbs.}$$

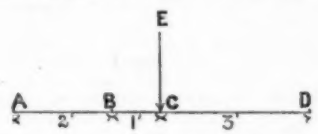
23. Define angular velocity.

Draw a straight line and mark on it four points in order, A, B, C, D; let AB, BC, CD be respectively 2 ft., 1 ft., 3 ft.; suppose a particle to be at C, moving at right angles to AD at the rate of 4 ft. a second; find its angular velocity with reference to A, B, and D respectively.

In what respect does the angular velocity with reference to A differ from the angular velocity with reference to D? (20)

If a body is describing a circle, the angle through which the radius joining the body with the centre revolves in one unit of time is called the angular velocity of the body round the centre.

If uniform, it is measured by the angle (in radians) described in unit of time; if variable, by the angle which would have been described in unit of time if the angular velocity at the instant in question were maintained constant for so long.




Let EC be the direction of motion.

Then angular velocity with reference to $A = -\frac{V}{r} = -$ .

" " " " $B = -\frac{4}{1} = -4$.

" " " " $D = \frac{4}{3}$.

As will be seen by the signs, the angular velocities when referred to A and D as centres, respectively, are equal in magnitude, but opposite in direction.

24. The densities of two liquids are in the ratio of 4 : 5; when certain volumes are mixed, the volume of the mixture is found to be one-eighteenth part less than the sum of the separate volumes, and the density of the mixture to be to that of the former liquid as 9 : 8; find the ratio of the volume of the former liquid to that of the latter liquid. (25)

Let $V_1$ and $V_2$ be the separate volumes respectively.

Let $V_3$ be the volume of the mixture.

Now density of the first : density of second : density of mixture as 4 : 5 : $4\frac{1}{2}$.

$$(V_1 + V_2) \times \tfrac{17}{18} = V_3 \quad (1)$$

$$\text{and } 4V_1 + 5V_2 = V_3 \times 4\tfrac{1}{2} \quad (2)$$

$$= (V_1 + V_2) \times \tfrac{17}{18} \times \tfrac{9}{2} \text{ from (1)};$$

$$\therefore 16V_1 + 20V_2 = 17V_1 + 17V_2.$$

$$\therefore V = \frac{V_1}{3}$$

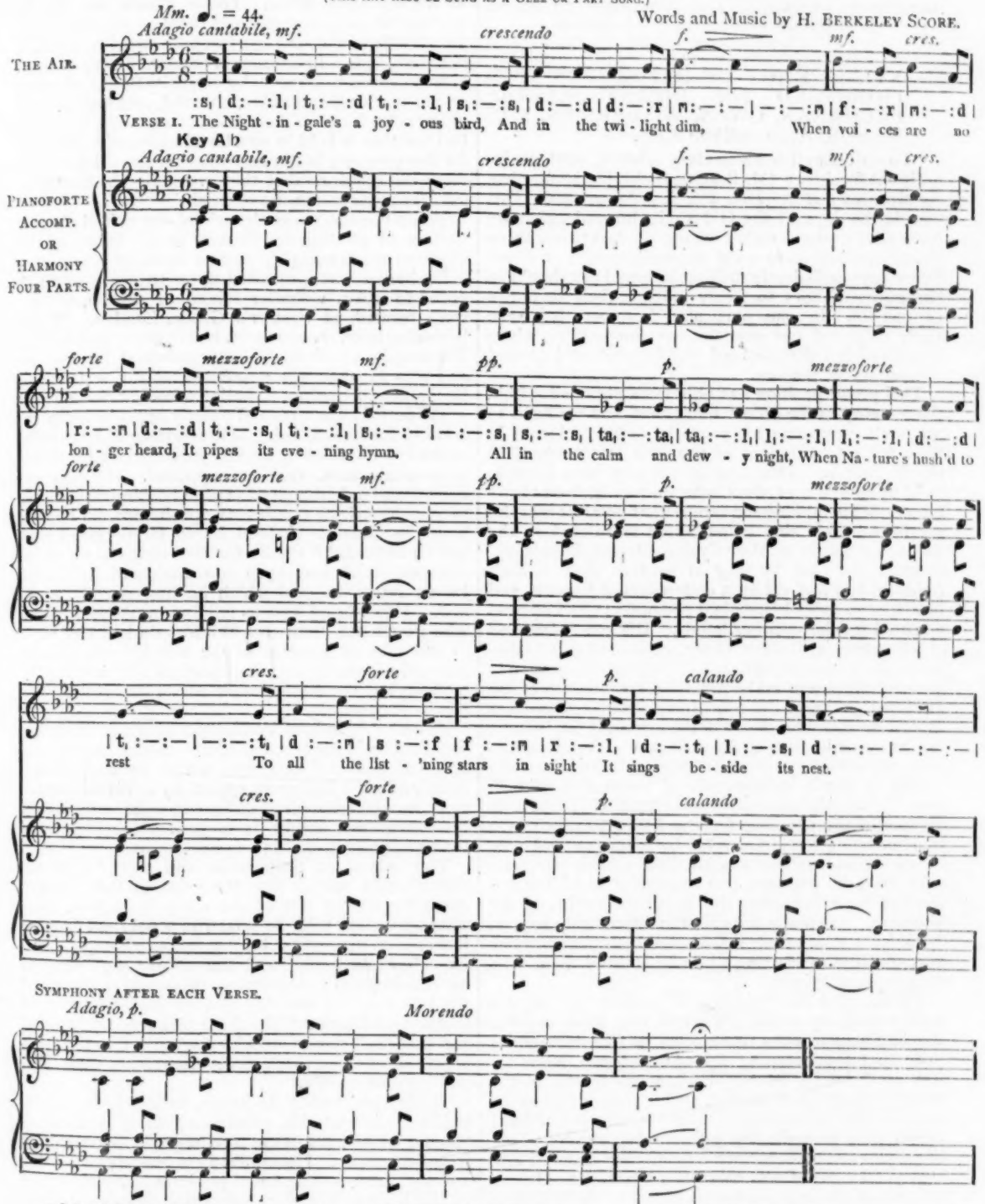
or $\therefore \dfrac{\text{volume of former liquid}}{\text{volume of latter liquid}} = \dfrac{V_1}{V_2} = \dfrac{3}{1}$.

(*To be continued.*)

# THE NIGHTINGALE.

## SONG FOR UPPER CLASSES IN A MIXED SCHOOL.

(This may also be Sung as a Glee or Part Song.)

Words and Music by H. Berkeley Score.

Mm. ♩. = 44.
Adagio cantabile, mf.
crescendo
f.
mf.
cres.
The Air.
:s1 | d:—:l1 | t1:—:d | t1:—:l1 | s1:—:s1 | d:—:d | d:—:r | m:—:—|—:—:m | f:—:r | m:—:d |
Verse 1. The Night - in - gale's a joy - ous bird, And in the twi - light dim, When voi - ces are no
Key A♭
Pianoforte Accomp. or Harmony Four Parts.
forte
mezzoforte
mf.
pp.
p.
| r:—:m | d:—:d | t1:—:s1 | t1:—:l1 | s1:—:—|—:—:s1 | s1:—:s1 | ta1:—:ta1 | ta1:—:l1 | l1:—:l1 | l1:—:l1 | d:—:d |
lon - ger heard, It pipes its eve - ning hymn, All in the calm and dew - y night, When Na - ture's hush'd to
tp.
| t1:—:—|—:—:t1 | d:—:m | s:—:f | f:—:m | r:—:l1 | d:—:t1 | l1:—:s1 | d:—:—|—:—:—|
rest To all the list - 'ning stars in sight It sings be - side its nest.
calando
Symphony after each Verse.
Adagio, p.
Morendo

2. It is a little brownish bird,
And comes to us in Spring;
But very soon its voice is heard,
Delightful in its ring.
It makes a tiny nest among
Some bushes near a stream;
And there it pipes its happy song
'Neath moon and stars' bright beam.

3. In Autumn cold it flies away
To some far warmer clime,
And then we miss its cheering lay,
So drear is evening time.
But very soon when winter's o'er,
And bleak snow storms have passed,
It gladly comes to us once more
With mem'ries of the past.

4. In this hard world of weary care
We often feel so sad,
For round us comes old 'Grim Despair,'
And nothing makes us glad.
Oh! then for some true 'guide' or 'friend,'
Some 'Nightingale of song,'
Who'll cheer us to the very end,
And steer us safe from wrong.

the mark with distilled water. Aliquot parts are taken out with a pipette, added to a solution of pure potassium iodide, and the liberated iodine titrated by the thiosulphate solution. From the quantity of Cu taken and the c.c. of 'thio' used, the value of the latter in grams of iodine per c.c. can be readily calculated.

(*b*) Potassium permanganate similarly liberates iodine, thus:— $K_2Mn_2O_8 + 14H_2SO_4 + 10KI = 12KHSO_4 + 2MnSO_4 + 8H_2O + 5I_2$. A weighed quantity of permanganate is made up to one litre, portions added to excess of KI dissolved in pure dilute sulphuric acid, and titrated as above.

(*c*) The iodine is resublimed, dried over sulphuric acid, a quantity weighed into a litre flask, dissolved in pure potassium iodide solution, made up to one litre, and portions titrated as in (*a*).

The reaction between thiosulphate and iodine may be represented as a condensation, thus—$2Na_2S_2O_3 + I_2 = 2NaI + Na_2S_4O_6$.

EXERCISES.

*Advanced Stage.*—(12) Give a rough plan of a plant for the production of sulphuric acid on a large scale, and give some account of the use of each part of the works represented. (13) What is understood by the term 'atmolysis'? Give any instances of the use of methods depending on atmolysis for the distinction between gaseous mixtures and compounds. Describe briefly one such method.

*Advanced Practical.*—(7) Name the impurities met with in dry sodium carbonate. How would you detect each of these impurities? Using the fusion method of examination for aluminium in presence of iron, how could you avoid using this carbonate? Explain the reactions involved. (8) How would you proceed to detect a nitrate in presence of a relatively large proportion of a bromide?

*Honours.*—(11) Describe the method you would adopt for the estimation of alkalies in a felspar. (12) Give a short account of Mallett's researches on the atomic weight of aluminium.

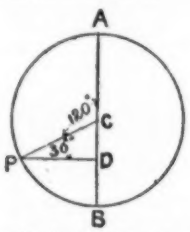
## SOLUTIONS TO QUESTIONS IN THEORETICAL MECHANICS.

BY F. CASTLE, M.I.M.E.

*Continued from p.* 386.

22. What is meant by the pressure of a fluid at a point? A is the highest point of the vertical diameter of a sphere whose centre is C; the sphere is hollow and full of water; P is a point on the inner surface such that PCA is 120°; find the horizontal and vertical components of the pressure at P. Find also numerical values for the components in pounds per square foot, the radius being 3 ft. (N.B.—Assume that a cubic inch of water weighs 252 grains.) (20)

The pressure at any point in any direction is an expression to denote the average pressure per unit of area on a plane surface, imagined as containing the point, and perpendicular to the direction in question, when the area of that surface is made indefinitely small; or, is the pressure on unit area at a depth equal to the depth of the point.




Draw PD perpendicular to AB, and meeting AB at D; then AD is the depth of point P and $AD = \frac{3}{2}r$. Hence pressure at $P = 1 \times \frac{3}{2}r \times w = \frac{3r \times w}{2}$, where $w$ = weight of unit vol. of the liquid.

Horizontal component of pressure at P

$$= \frac{3r}{2} \times w \times \cos CPD$$

$$= \frac{3r}{2} \times w \times \cos 30°$$

$$= \frac{3\sqrt{3}}{4} \times r \times w.$$

Vertical component of pressure at P

$$= \frac{3r}{2} \times w \times \sin CPD$$

$$= \frac{3r}{2} \times w \times \sin 30°$$

$$= \frac{3rw}{4}.$$

$\therefore$ Horizontal component

$$= \frac{3 \times 3 \times 252 \times 1728 \times \sqrt{3}}{4} \text{ grains}$$

$$= \frac{9 \times 252 \times 1728 \times \sqrt{3}}{4 \times 16 \times 20 \times 24} \text{ lbs.}$$

$$= 220{\cdot}96 \text{ lbs.}$$

Vertical component

$$= \frac{3 \times 3 \times 252 \times 1728}{4 \times 16 \times 20 \times 24} \text{ lbs.}$$

$$= 127{\cdot}57 \text{ lbs.}$$

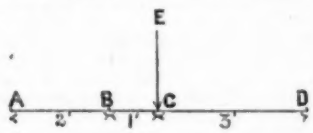
23. Define angular velocity.

Draw a straight line and mark on it four points in order, A, B, C, D; let AB, BC, CD be respectively 2 ft., 1 ft., 3 ft.; suppose a particle to be at C, moving at right angles to AD at the rate of 4 ft. a second; find its angular velocity with reference to A, B, and D respectively.

In what respect does the angular velocity with reference to A differ from the angular velocity with reference to D? (20)

If a body is describing a circle, the angle through which the radius joining the body with the centre revolves in one unit of time is called the angular velocity of the body round the centre.

If uniform, it is measured by the angle (in radians) described in unit of time; if variable, by the angle which would have been described in unit of time if the angular velocity at the instant in question were maintained constant for so long.




Let EC be the direction of motion.

Then angular velocity with reference to $A = -\frac{V}{r} = -$ .

" " " " $B = -\frac{4}{1} = -4$.

" " " " $D = \frac{4}{3}$.

As will be seen by the signs, the angular velocities when referred to A and D as centres, respectively, are equal in magnitude, but opposite in direction.

24. The densities of two liquids are in the ratio of 4 : 5; when certain volumes are mixed, the volume of the mixture is found to be one-eighteenth part less than the sum of the separate volumes, and the density of the mixture to be to that of the former liquid as 9 : 8; find the ratio of the volume of the former liquid to that of the latter liquid. (25)

Let $V_1$ and $V_2$ be the separate volumes respectively.

Let $V_3$ be the volume of the mixture.

Now density of the first : density of second : density of mixture as 4 : 5 : $4\frac{1}{2}$.

$$(V_1 + V_2) \times \tfrac{17}{18} = V_3 \quad (1)$$

$$\text{and } 4V_1 + 5V_2 = V_3 \times 4\tfrac{1}{2} \quad (2)$$

$$= (V_1 + V_2) \times \tfrac{17}{18} \times \tfrac{9}{2} \text{ from (1);}$$

$$\therefore 16V_1 + 20V_2 = 17V_1 + 17V_2.$$

$$\therefore V = \frac{V_1}{3}$$

$$\text{or } \therefore \frac{\text{volume of former liquid}}{\text{volume of latter liquid}} = \frac{V_1}{V_2} = \frac{3}{1}.$$

(*To be continued.*)

# THE NIGHTINGALE.

## SONG FOR UPPER CLASSES IN A MIXED SCHOOL.

(This may also be Sung as a Glee or Part Song.)

Words and Music by H. Berkeley Score.

*Mm.* ♩. = 44.

*Adagio cantabile, mf.* *crescendo* *f.* *mf.* *cres.*

The Air.

:$s_1$ | d: — : $l_1$ | $t_1$ : — : d | $t_1$ : — : $l_1$ | $s_1$ : — : $s_1$ | d: — : d | d: — : r | m: — : — | — : — : m | f: — : r | m: — : d |

Verse 1. The Night - in - gale's a joy - ous bird, And in the twi - light dim, When voi - ces are no

Key A ♭

*Adagio cantabile, mf.* *crescendo* *f.* *mf.* *cres.*

Pianoforte Accomp. or Harmony Four Parts.

*forte* *mezzoforte* *mf.* *pp.* *p.* *mezzoforte*

| r: — : m | d: — : d | $t_1$ : — : $s_1$ | $t_1$ : — : $l_1$ | $s_1$ : — : — | — : — : $s_1$ | $s_1$ : — : $s_1$ | $ta_1$ : — : $ta_1$ | $ta_1$ : — : $l_1$ | $l_1$ : — : $l_1$ | $l_1$ : — : $l_1$ | d: — : d |

lon - ger heard, It pipes its eve - ning hymn, All in the calm and dew - y night, When Na - ture's hush'd to

*forte* *mezzoforte* *mf.* *pp.* *p.* *mezzoforte*

*cres.* *forte* *p.* *calando*

| $t_1$ : — : — | — : — : $t_1$ | d : — : m | s : — : f | f : — : m | r : — : $l_1$ | d : — : $t_1$ | $l_1$ : — : $s_1$ | d : — : — | — : — : — |

rest To all the list - 'ning stars in sight It sings be - side its nest.

*cres.* *forte* *p.* *calando*

Symphony after each Verse.

*Adagio, p.* *Morendo*

2. It is a little brownish bird,
And comes to us in Spring;
But very soon its voice is heard,
Delightful in its ring.
It makes a tiny nest among
Some bushes near a stream;
And there it pipes its happy song
'Neath moon and stars' bright beam.

3. In Autumn cold it flies away
To some far warmer clime,
And then we miss its cheering lay,
So drear is evening time.
But very soon when winter's o'er,
And bleak snow storms have passed,
It gladly comes to us once more
With mem'ries of the past.

4. In this hard world of weary care
We often feel so sad,
For round us comes old 'Grim Despair,'
And nothing makes us glad.
Oh! then for some true 'guide' or 'friend,'
Some 'Nightingale of song,'
Who'll cheer us to the very end,
And steer us safe from wrong.

## MODERN EDUCATIONAL REFORMERS.

BY THOMAS CARTWRIGHT, B.A., B.SC. (LOND.),
*Author of 'Mental Science and Logic for Teachers.' Late Director of the Birkbeck Training Classes and Lecturer therein on School Method.*

### No. XVI.—A KNOT OF REFORMERS WHO PIONEERED THE INFANT SCHOOL: BUCHANAN, OWEN, WILDERSPIN, THE MAYOS, AND REYNOLDS.

'To visit English elementary schools,' said an intelligent foreigner (M. Braun), 'is highly instructive, *for there you find everything that should be avoided.*' This was in the days of the Old Code, beyond which we have advanced somewhat during the last two or three decades, albeit there exist anomalies, even in these latter days, sufficiently striking to impel our shoulder-shrugging visitors to freely indulge their favourite propensity. In one particular, however, we have fairly outpaced our over-the-sea competitors, since the English Infant School stands confessed second to none under the sun.

This proud position has only been obtained within the memory of the oldest inhabitant, and we have to go back only some 100 years in order to locate in time the establishment of the first infant school in Great Britain. This was in 1783, at New Lanark, hard by the falls of the Clyde, and to Robert Owen the credit for making the experiment possible must be ascribed. How this came about is related in the following words in the 'Cyclopædia of Education.' It must be said by way of preface that Owen's father-in-law had set up a cotton mill at Lanark, and in response to his benevolent promptings had opened a school for the younger hands. His son-in-law and chief successor, Robert Owen, continued and elaborated the school experiment, circumstances gradually compelling him to make provision for children of the tenderest years, as the sequel will show. 'There was at first no intention of providing specially for infants, but as no child that could walk was refused admission, the school was soon overrun with little ones too young to profit by any mode of instruction then in use. They might possibly have been sent home to be out of the way, but for the happy accident of a teacher being found just fitted by nature to deal with them. This teacher was Mr. James Buchanan, who possessed the patience, tact, sympathy, and invention needful for overcoming the novel difficulties of the situation. He made the children thoroughly happy; he did not weary their little brains with books, yet he succeeded in instructing while he amused them with pictures and objects.'

To his other admirable qualities must be added a native modesty which prevented him from seeking any applause or even recognition, so that history has little to tell concerning this canny Scot. None the less must he be honoured when the annals of the infant school are compiled, seeing that his aims no less than his practice were worthy precursors of those which have brought the primary department of our elementary schools to such a gratifying state of efficiency. In proof of this let us cite Mr. Owen's account of the experiment, as given to the House of Commons in 1816: 'The children are received into a preparatory training school at the age of three, in which they are perpetually superintended to prevent them acquiring bad habits, to give them good ones, and to form their dispositions to mutual kindness and a sincere desire to contribute all in their power to benefit each other. These effects are chiefly accomplished by example and practice, precept being found of little use, and not comprehended by them at this early age. Instruction is combined with as much amusement as is found to be requisite for their health, and to render them active, cheerful, and happy, fond of the school and of their instructors. The school in bad weather is held in apartments properly arranged for the purpose, but in fine weather the children are much out of doors, that they may have the benefit of sufficient exercise in the open air.'

When the success of the school was noised abroad, visitors of all degrees flocked to the banks of the Clyde to see the mighty wonder for themselves.

Buchanan was prevailed upon to come south in order to open a similar school, or asylum, as they were termed, at Brewer's Green, London. Whilst labouring here, chance threw him in the way of Samuel Wilderspin, to whom he communicated his system, and who in 1820 was appointed, at the instance of Buchanan, to conduct a similar school at Spitalfields.

Wilderspin was a man of exactly opposite temperament to Buchanan, being self-assertive and morbidly intent upon obtaining full and public credit for all his accomplishments, real or supposed. He was endowed with a double portion of the commodity known to our American cousins as 'push,' nor did he lack belief in himself. Indeed, he so far deceived himself (?) as to claim credit for the very system of instruction which had been communicated to him by James Buchanan, and which he had slightly modified. This caused him to fall foul of Robert Owen, who would not allow that Wilderspin had any right to the title of inventor of the new system of infant instruction, contending that his chief achievement lay in changing the name infant *asylum* into infant *school*—a happy thought.

The best friends of Wilderspin agree in deploring that he should have made claim to the introduction of principles and practices which he undoubtedly mainly owed to Buchanan, especially as his missionary work in advancement of infant education, no less than his exceptional ability as a gallery teacher, more than justified his claim to consideration.

The school at Spitalfields did not begin too auspiciously, seeing that the cries of the children drove the master out of the room in despair. Returning, we are told, he seized on a pole and dangled thereupon his wife's bright coloured cap. This expedient succeeded, and the master thus remarks on the incident: 'Revolving these circumstances, I felt that that new morning had not passed in vain. I had in fact found the clue.' It was now evident that the children's senses must be engaged, that the great secret of teaching them was to descend to their level and become a child.

Wilderspin, unlike Buchanan, soon began to draw public attention to his efforts, and succeeded in convincing his visitors of the dire necessity for reform in infant education. His efforts were entirely successful, and soon he was to be found perambulating the whole of the United Kingdom preaching the gospel of the instruction of children of tender age in the Wilderspin vogue, so that he is aptly spoken of as Organiser-in-Chief of the infant schools of Great Britain.

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In his 'Infant Education' he gives a lively account of many of these visits of propaganda.

With Stow he went through Scotland lecturing and demonstrating and establishing schools, the excellence of which he attempted to prove by public examination of the children who had been under the fostering care of the system for a few months! This was examination run mad, and to it may perhaps be due the almost superstitious belief of the average Englishman in the efficacy of and the necessity for payment by results. Be this as it may, we cannot but admire the energy shown by Wilderspin, and his unceasing disregard for the discomfort inseparable from journeyings to and fro, the extent of which may be judged from the fact that he crossed over to Ireland no less than 17 times, intent upon the initiation of schools in accordance with what he termed *his system*, but which justice would attribute to James Buchanan.

Another outcome of the noise made in the world by Wilderspin was the establishment, in 1824, of the London Infant School Society, the decease of which, however, he had to deplore a few years hence.

At this period the Irish educational authorities entered into negotiation with Wilderspin, the outcome of which was the appointment of the lecturer to the post of Director-in-General of schools to be established in Ireland, at a salary of £500 per annum. This post he did not long occupy, his dismissal being due, according to himself, to a wholesale ejection of Protestant officials. Another and more likely solution is that he was found of too slender ability and acquirements for such a weighty office. Still he was not permitted to languish without due recognition, since an appreciative Prime Minister had placed his name upon the Civil List, and to his dying day he continued to draw a pension, to which his energetic pioneering work had certainly entitled him.

His wife had nobly seconded the efforts of her husband, she practically managing the 200 children who flocked to the Spitalfields School, and it is to be feared that her death was in some measure due to the undue demands made upon her by the arduous nature of her work, hence the first infants' schoolmistress may be in some measure counted as a martyr to the cause. Strange it is to note that, notwithstanding the success of his wife, Wilderspin was a disbeliever in women-teachers, although he was an earnest and consistent advocate of mixed schools. 'I never knew,' quoth he, 'a little girl fall on the playground without a little boy helping her up, or a little boy hurt himself without some little girl or girls running to soothe and assist him.'

Like David Stow, he attached great importance to the playground, especially with respect to the moral education of his charges, and he recommends strict supervision of the children in order that the lessons of the 'uncovered playground' may in no wise be lost.

One piece of apparatus, viz., the *Ball-Frame*, must always, in justice, be associated with the name of Samuel Wilderspin, for, notwithstanding its resemblance to the abacus of the Romans, there is no room for doubt but that Wilderspin, in his efforts to teach arithmetic concretely, hit upon this happy device independently, and it is an important proof of the rightness of his instincts that he should have found such a contrivance necessary.

From the two works of Wilderspin we make a few quotations by way of showing what manner of opinions were held by the doughty organiser-in-chief to the British nation in the matter of rational infant schools, first reminding our readers that the claim of our island-trotter to fame and recognition depends upon his deeds and not upon his writings, which, it must be confessed, albeit in some respects savouring of Pestalozzi and Froebel, indicate no great degree either of erudition or of inventive capacity.

We learn that Wilderspin as a child was wont to roam about the fields of Hornsey 'chewing the food of sweet and bitter fancy,' and finding 'tongues in trees, books in the running brooks, sermons in stones, and good in everything,' and his mother played the parental part suggested by Herbert Spencer, encouraging him to inquiry concerning objects and readily answering his questions.

Thus the organiser learnt to think, and therefore he tells us he would have his scholars thoughtful and inquiring. To foster this spirit he advocates the supply of suitable objects—an excellent plan, having its counterpart in the modern system of object lessons. 'A great secret in teaching the young,' says he, 'is to teach them through the senses. Objects of all kinds are to be introduced and oral lessons given upon them to teach them their qualities and properties.' In this connection it may be recorded that Wilderspin was admitted on all sides to be an eminent gallery teacher. Again as to *development*:—'The system pourtrayed in this book is intended to aid the use of the faculties of a child, especially the highest, to feed these faculties with suitable food, to amplify and explain everything so as to adapt it properly to those faculties, and ever to blend both exercise and amount of instruction at due intervals, which is readily effected by a moderate amount of singing alternating with the usual notes and evolutions in the schoolroom and the unfettered freedom of the playground.'

He distinctly connects the crime of his time with the neglect of education, a contention shown to be true in our day by the gratifying diminution of both juvenile and adult delinquency.

Furthermore, he showed a wise discrimination in the matter of punishment, therein exhibiting a sagacity which many of our so-called educationists of to-day would do well to emulate. 'It is common with many persons to put a disobedient child in a room by itself. I cannot approve of this method, as the child is frequently frightened into quietness without improving his temper in the least; if it be daytime it is not so bad, but if it be dark the consequences are often serious and materially injure the condition of the child. The more I reflect upon this question, the more do I see its impropriety. I would rather use the rod in moderation and mercy. I am sure it is better for the disobedient and unruly child, and more according to the dealings of Christ with us all. I can truly say that my punishments which have been slight have done me good. As children, we cannot see these things; as men and thinkers, we can. Yea! and kiss the rod.'

In many, indeed in most, other respects the practice and theory of Samuel Wilderspin were such as would commend themselves to latter-day pedagogues, and it is certain that his name would to-day be in better odour were we not constrained to admit that

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he made no adequate acknowledgment of his indebtedness (which could not but have been great) to James Buchanan, and that he was too prone to boasting and bombast, which

> 'Take
> From our achievements, though performed at height,
> The pith and marrow of our attribute.'

Two whimsicalities, and of Wilderspin we take our leave.

A Scotch urchin had been duly received into one of Wilderspin's establishments in the 'land of brown heath and shaggy wood,' and had been instructed in the mysteries of the ball-frame. His maternal parent, upon his returning home, was naturally anxious for him to report progress, hence the following dialogue:—'Well, Sandy, what hae ye been at?' 'Eh! mither, we've been counting the beads.' And it took both time and eloquence to persuade the Calvinistic mother that the said beads were a device to further the study of arithmetic and not a Romish trap to catch Protestants.

The second narrative requires some amount of faith, especially as it relates to Cheshire—a county in which Wilderspin, after his Irish experience, had but a poor reception, and against which he inveighed in good set terms:—'The mistress of a school who had charge of 70 children came to a school, which I was then organising, in order to be instructed in the Infant System, and, it being always a maxim with me to put persons coming to be taught to something at once, I desired her to take the alphabet class, when, to my astonishment, she at once told me *she could not read, nor did she know even the alphabet, and yet this woman had been actually engaged by a Committee and had filled the office of a teacher for three years.*' We have had a very poor opinion of the beginning-of-the-century teacher, but a mistress of three years' standing who did not know her alphabet certainly deserves to be rescued from oblivion.

Reference to the first beginnings of English infant schools would be culpably incomplete if Dr. Mayo and his sister, of Cheam, were not honourably included therein. From 1818 to 1821 the worthy Doctor was at Yverdun sitting at the feet of Pestalozzi, and, as a result of this visit, a Pestalozzian school was established at Cheam, from which sprang many offsets. In addition, Dr. Mayo, in 1826, lectured on Pestalozzi's system at the Royal Institution, and made many converts, with one of whom, Mr. Jno. Stuckey Reynolds, Dr. Mayo laboured long and arduously to put the teaching of English children of tender age upon a more satisfactory basis. And the monument of these labours, is it not to be seen to-day in the shape of the Home and Colonial Training College, established in 1836 for the supply of properly trained infant school teachers?

In conclusion, we shall be content if we have engendered a spark of gratitude in the breasts of our readers towards Owen, Buchanan, Wilderspin, the Mayos, and Reynolds, to whom the elementary education of this England of ours owes so much. This was our aim at the onset, this is our hope at the conclusion, 'in the which hope we blush and hide our *pen*.'

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The following are the Questions given for the different Standards:—

### STANDARD V.

#### SECTION I.

[*Only* ONE *Question may be answered in this Section.*]

1. Quote the verses in which St. Paul describes the equipment of the Christian soldier. Why is faith compared to a shield, and the word of God to a sword?

2. Quote the five verses in praise of Charity, beginning, 'Charity suffereth long.' Explain the verse, 'Beareth all things, hopeth all things, endureth all things.'

3. Quote a few verses from the Proverbs in praise of truthfulness. Explain the verse, 'The lip of truth shall be established for ever, but a lying tongue is but for a moment.'

#### SECTION II.

[*Only* TWO *Questions may be answered in this Section.*]

1. Give the story of David's numbering the people, and of its consequences. In what do you think the sinfulness of David's conduct consisted?

2. How did Rehoboam show himself to be a foolish king at the beginning of his reign?

3. Relate the story of Elijah's visit to Mount Horeb. What lessons may we learn from what happened to the prophet there?

4. Give a short account of the work which King Josiah did in the service of God.

#### SECTION III.

[*Only* THREE *Questions may be answered in this Section.*]

1. Relate the Parable of the Sower, and give our Lord's explanation of it. Can you give any example from the Bible to illustrate the stony ground and the thorny ground?

2. 'Daughter, thy faith hath made thee whole.' Relate the incident which led to our Lord's using these words, and say what you think the words mean.

3. What do you remember of our Lord's sayings when His disciples pointed out to Him the beauties of the Temple buildings?

4. Where was the Garden of Gethsemane? Give a short account of what St. Mark tells us happened there.

5. Relate the conversation of our Lord with the rich young man who came to Him. What further teaching did He give to His disciples in connection with this incident?

6. How did our Lord deal with His two disciples who wished to be first in His Kingdom? What lessons may we learn from this?

### STANDARD VI.

#### SECTION I.

[*Only* ONE *Question may be answered in this Section.*]

1. Write out the verses you have learnt from the Book of Proverbs which show the duty of Temperance. Explain what you understand generally by Temperance.

2. Write out the passage from Ephesians iv., beginning, 'I therefore the prisoner of the Lord,' to the words 'measure of the gift of Christ'; and explain from this passage, 'forbearing one another in love.'

#### SECTION II.

[*Only* TWO *Questions may be answered in this Section.*]

1. What do you understand by the following verses from Isaiah, chap. liii., verses 6 and 7?

VERB. SAP.

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'All we like sheep have gone astray: we have turned every one to his own way; and the Lord hath laid on him the iniquity of us all.' 'He was oppressed and he was afflicted, yet he opened not his mouth: he is brought as a lamb to the slaughter, and as a sheep before her shearers is dumb, so he openeth not his mouth.'

2. Show from the teaching of our Lord the truth of this verse from Isaiah, chap. lv.:—

'Let the wicked forsake his way, and the unrighteous man his thoughts: and let him return unto the Lord, and he will have mercy upon him; and to our God, for he will abundantly pardon.'

3. What lesson do you learn from Psalm xc., verse 5, 'So teach us to number our days that we may apply our hearts unto wisdom.'

4. Write out the story connected with this verse from Psalm cvi., 'They angered him also at the waters of strife, so that it went ill with Moses for their sakes,' and state what lessons you learn from the story.

### SECTION III.

[*Only* THREE *Questions may be answered in this Section.*]

1. What practical lessons do you learn from St. Matthew's account of the temptation of our Lord?

2. How does our Lord, in the Sermon on the Mount, teach us that we must not give undue thought to our bodily wants?

3. Relate the circumstances under which our Lord said, 'It is not meet to take the children's bread and to cast it to dogs.' Give the lessons to be learnt from the story.

4. In the Lord's Prayer we pray, 'And forgive us our debts, as we forgive our debtors.' What does this mean? Illustrate your answer by a parable of our Lord's related by St. Matthew.

5. 'Watch, therefore: for ye know not what hour your Lord doth come.' What Parable did our Lord deliver to illustrate these words, and what lesson do you learn from the Parable?

6. 'For this is my blood of the New Testament, which is shed for many for the remission of sins.' Under what circumstances were these words used?

## STANDARD VII.

### SECTION I.

[*Only* ONE *Question may be answered in this Section.*]

1. Write out the verses you have learnt from Proverbs that teach (*a*) Truthfulness, (*b*) Temperance. State exactly what you mean by Temperance.

2. What are the weapons with which St. Paul teaches us we ought to combat our spiritual enemies? What duties does this teach us besides that of withstanding temptation?

### SECTION II.

[*Only* TWO *Questions may be answered in this Section.*]

1. What was the charge that Zedekiah brought against Jeremiah when he shut him in prison in the tenth year of the king's reign?

2. What steps did Jeremiah take to assure the Jews that their captivity should not be permanent?

3. Give an account of the covenant made by the princes of Judah and the people as to keeping Jews in servitude. How was this covenant kept, and what did Jeremiah prophesy in consequence?

4. What two great powers threatened Judah in the time of Jeremiah? Which did Jeremiah say would conquer Judah? What did he say of the other power?

### SECTION III.

[*Only* THREE *Questions may be answered in this Section.*]

1. Mention any points that you know in which the Gospel of St. John differs from the other Gospels.

2. Mention any events in our Lord's life connected with Cana of Galilee, the Pool of Bethesda, and Bethany.

3. Describe shortly what took place during the meeting which Philip arranged between certain Greeks and Jesus.

4. Describe what took place at the house of the High Priest after Jesus had been betrayed as written by St. John. Why did not the High Priest complete the trial of Jesus himself?

5. Give an account of the work of Philip in Samaria. How and by whom was this work carried on? What Philip was this?

6. What dispute in the Church of Antioch led the Apostles to consult the Church in Jerusalem? How was the dispute decided?

## EX.-STANDARD VII.

### SECTION I.

[*Only* THREE *Questions may be answered in this Section.*]

1. 'And God Almighty bless thee . . . . and give thee the blessing of Abraham; to thee, and to thy seed with thee.' Who spake these words, and on what occasion? What was 'the blessing of Abraham'?

2. What are the chief lessons you should learn from reading the history of—

(*a*) Esau and Jacob?
(*b*) Jacob and his sons?
(*c*) Joseph and his brethren?

3. What account is given of Ishmael in the Book of Genesis?

4. Give the substance of Jacob's dying blessing on Judah or on Joseph.

5. Explain the following passages:—

(*a*) 'And Joseph brought unto his father their evil report.'
(*b*) 'Take, I pray thee, my blessing that is brought to thee' (from the address of Jacob to Esau on return from Padan-Aram).
(*c*) 'Now the Lord had said unto Abram . . . . thou shalt be a blessing.'

### SECTION II.

[*Only* THREE *Questions may be answered in this Section.*]

1. 'And they came unto him bringing one sick of the palsy, which was borne of four.' Relate the circumstances which followed, and give the substance of what Jesus said on the occasion. What may we learn from His words?

2. In His explanation of the Parable of the Sower, what meaning does our Lord give to the seed which fell by the wayside, to that which fell on stony ground, and to that which fell among thorns?

3. Give some examples of great faith as recorded in St. Mark's Gospel.

4. 'This people draw near me with their mouth, and with their lips do honour me, but have removed their heart far from me,' Isaiah, chap. xxix., verse 13. How did Jesus apply this saying to the teaching of the Pharisees?

5. Explain the following passages:—

(*a*) 'Whosoever will come after me, let him deny himself, and take up his cross, and follow me.'
(*b*) 'Render to Cæsar the things that are Cæsar's, and to God the things that are God's.'
(*c*) 'The spirit truly is ready, but the flesh is weak.'

6. Give, from St. Mark's Gospel, some of our Lord's teaching with regard to *Riches*, *Forgiveness of others*, *Alms-giving*, and *Rash Judgment*.

Candidates for Pupil-Teachership had to take the Questions set for Standard VII., as above.

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Let *a* represent in inches the remaining segment of the hypotenuse.

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Then hypotenuse $= (a + 12)$ inches;

$$\therefore \frac{8^2}{a + 12} = a.$$

$$a^2 + 12a = 64.$$

(We *must* work this as a quadratic equation.)

$$a^2 + 12a + 6^2 = 64 + 36$$
$$= 100.$$
$$a + 6 = 10.$$
$$a = 10 - 6.$$
$$\therefore a = 4.$$

$\therefore$ Remaining segment $= 4$ inches.

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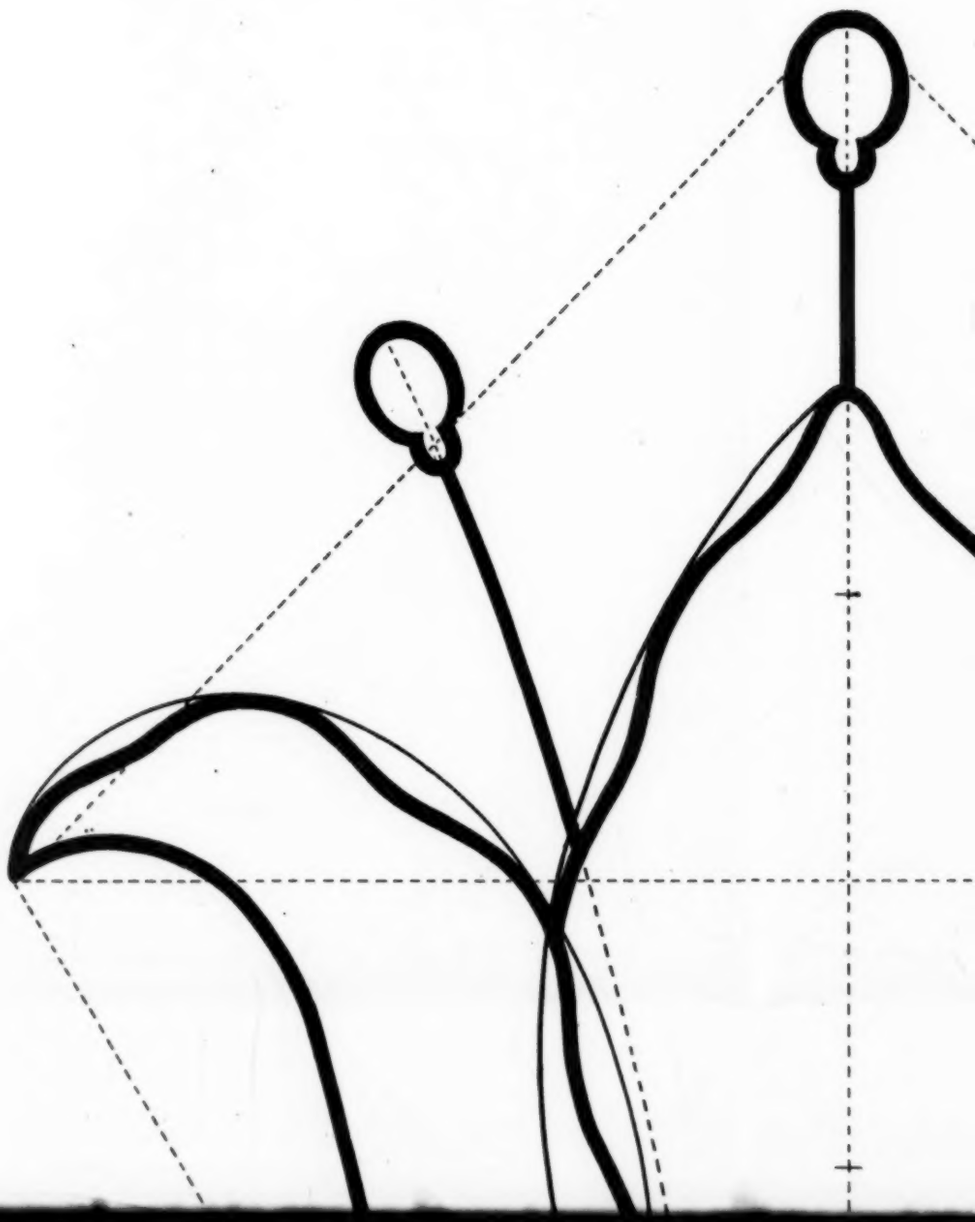

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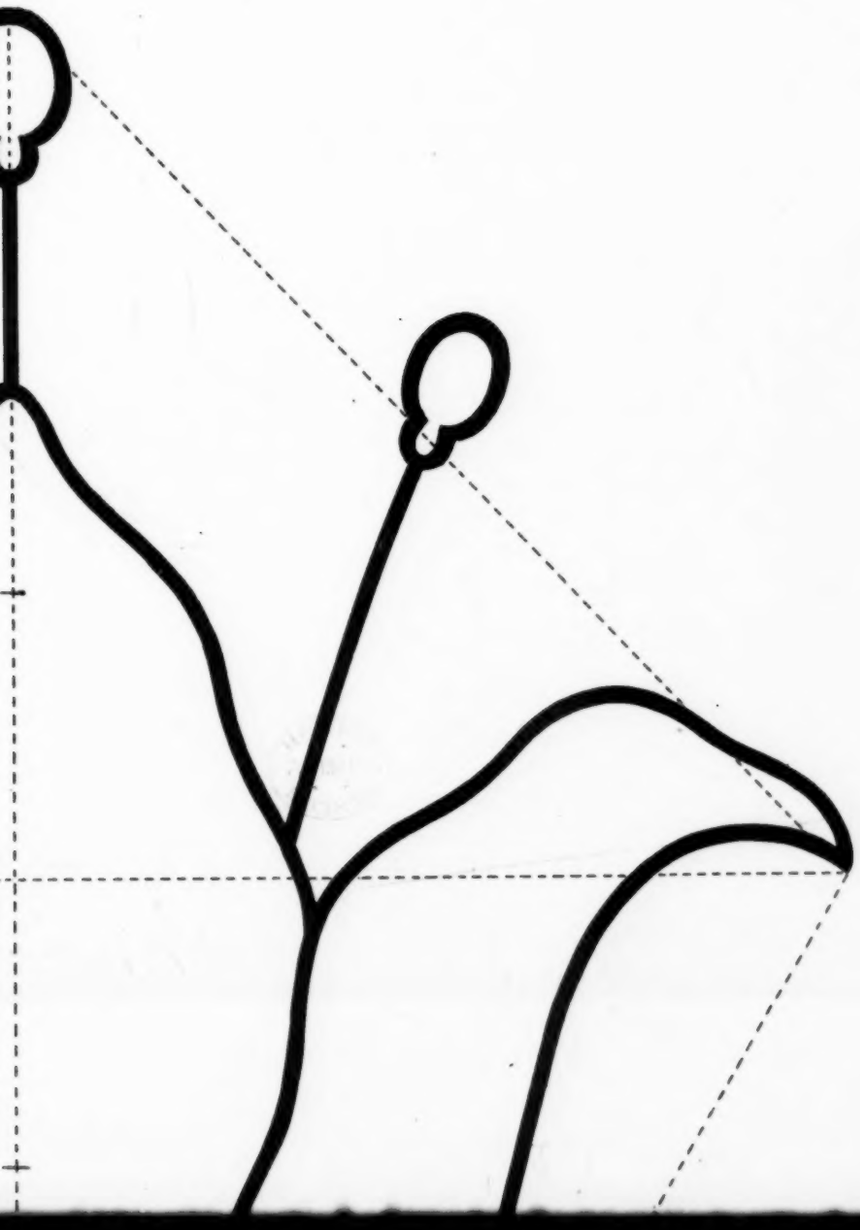

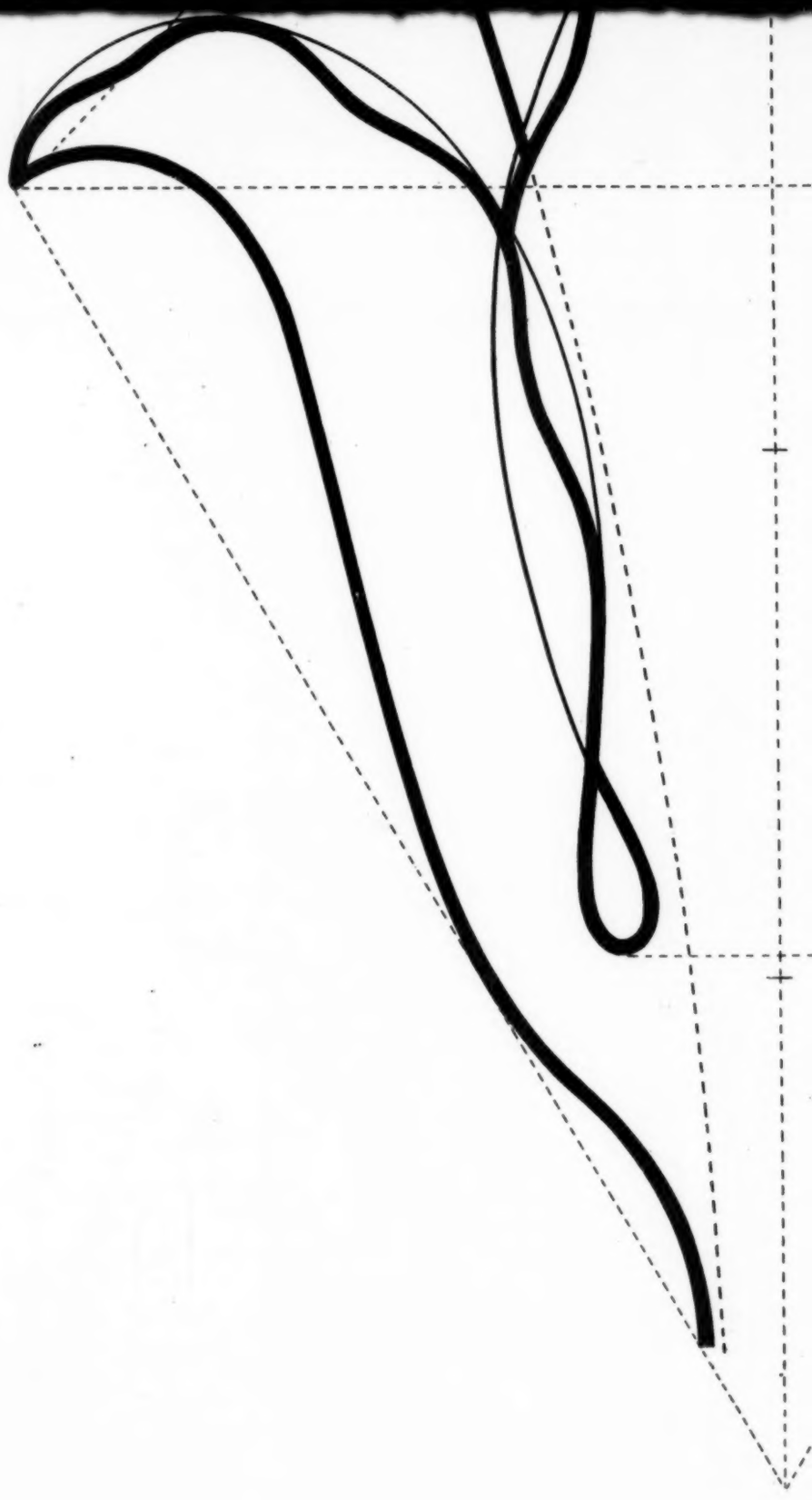

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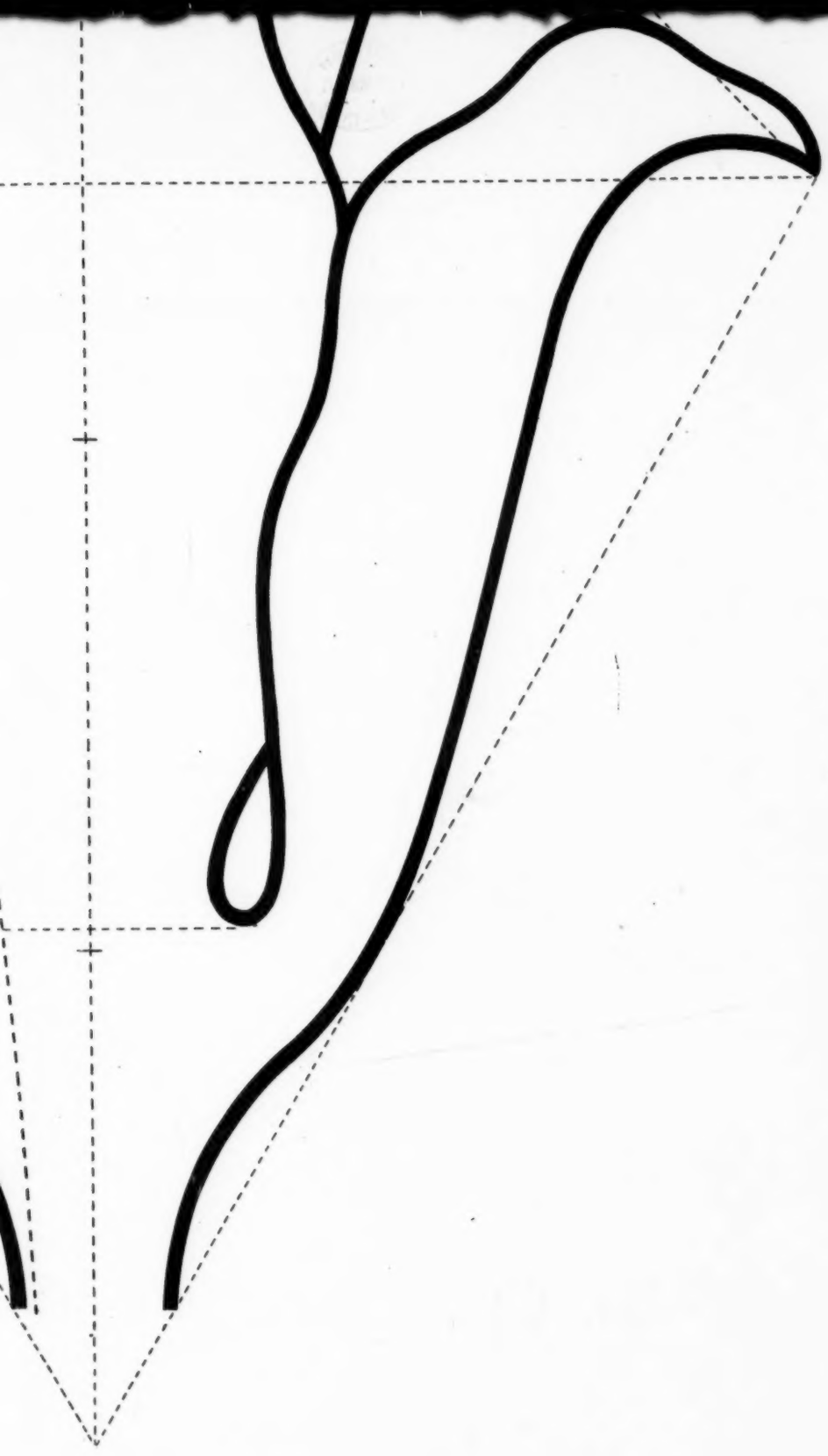

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